separate mixtures of *d*-glucoheptulose and *α*-*d*-glucoheptose.

2. When *d*-glucoheptulose was reduced with sodium amalgam *β*-*d*-glucoheptitol and a substance which Khouvine and Nitzberg have called *α*-*d*-glucoheptulitol were obtained.

3. Evidence has been presented to show that the substance called *α*-*d*-glucoheptulitol is not a pure chemical entity but consists of mixed crystals of *α*-glucoheptitol plus a small amount of an optically active impurity. This evidence is, briefly:

From the values obtained in elementary analyses and in molecular weight determinations it is not possible to write a formula which is consistent with the chemical behavior of the substance.

The substance when heated in a 10% solution of sulfuric acid goes over into *α*-glucoheptitol.

The substance when treated with acetic anhydride and a catalyst forms the heptaacetate of *α*-glucoheptitol.

The substance when treated with trityl chloride in the presence of pyridine forms the ditrityl derivative of *α*-glucoheptitol.

A saturated solution of *α*-glucoheptitol in methanol is also saturated with respect to this substance.

CHICAGO, ILLINOIS RECEIVED AUGUST 26, 1939

[CONTRIBUTION FROM THE RESEARCH LABORATORIES OF THE UNIVERSAL OIL PRODUCTS COMPANY]

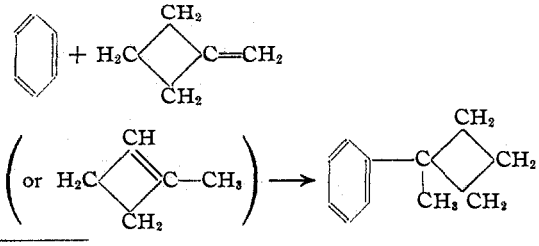
Reaction of Benzene with Methylcyclobutene and Methylenecyclobutane in the Presence of Sulfuric Acid[1]

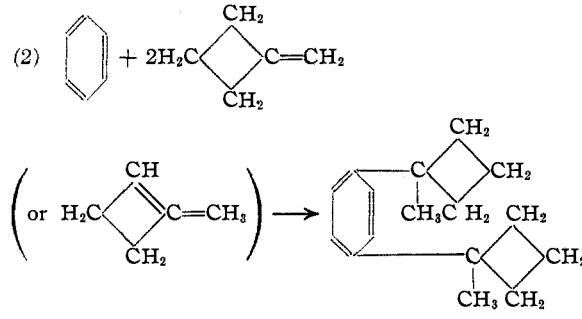
BY V. N. IPATIEFF AND HERMAN PINES

The reaction between alkenes and aromatic hydrocarbons proceeds readily in the presence of various condensing agents.[2] Of the cycloalkenes only those containing five- and six-membered rings have been studied.

We were interested in studying the reaction of benzene with a cycloalkene containing a four-membered ring, in order to determine whether methylcyclobutylbenzene would be formed and whether a cyclobutyl group attached to a phenyl group is more stable than an unarylated cyclobutane. It was found that a mixture composed of methylcyclobutene and methylenecyclobutane reacts readily with benzene in the presence of 96% sulfuric acid at 0–10° to yield a product consisting of mono-, di- and trimethylcyclobutylbenzenes.

The reaction proceeds according to the equation

(1) 

(2) 

The monosubstituted benzene, which is probably 1-methyl-1-phenylcyclobutane,[3] contains a cyclobutyl ring which is stable toward nitrating mixture consisting of 1 vol. concentrated nitric and 2 vol. of concentrated sulfuric acid. A nitro compound was obtained from which a solid monoacetamino derivative was prepared. The cyclobutyl ring in methylcyclobutane decomposes when subjected to similar treatment.

The di-substituted benzene consists mainly of *p*-di-(1[1]-methylcyclobutyl)-benzene which melts at 33–34°. The higher-boiling fractions consist of tri-(1[1]-methylcyclobutyl)-benzene.

The cyclobutyl ring in the di-substituted benzene is stable toward 2% potassium permanganate at 100° and toward dilute nitric acid at a

(1) Presented before the Division of Organic Chemistry of the American Chemical Society at Boston, Mass., Sept. 11–15, 1939.

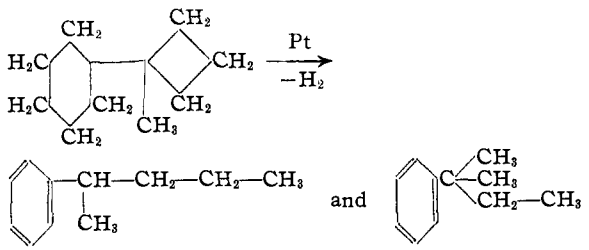
(2) Ipatieff, Pines and Schmerling, paper presented before the Organic Division at the American Chemical Society meeting, Milwaukee, Wisconsin, September, 1938.

(3) The position of the methyl group was not established, but on the basis of reaction of alkenes with benzene[2] one would expect the phenyl group to attach itself to the carbon atom of cyclobutyl containing the methyl group.

temperature of 135°. At 160° oxidation takes place yielding terephthalic acid.

The effect of hydrogen on the cyclobutyl ring was studied with 1-methyl-1-phenylcyclobutane, which undergoes hydrogenation at 65° in the presence of a solvent and a nickel catalyst to yield 1-methyl-1-cyclohexylcyclobutane; if the hydrogenation is carried out at 125° the cyclobutyl ring decomposes and amylcyclohexane is obtained.

The cyclobutyl ring in 1-methyl-1-cyclohexylcyclobutane decomposes when passed over platinized alumina at 250°; a mixture of *t*-amylbenzene and 2-phenylpentane was obtained. This proceeds according to the equation



The percentage of the two amylbenzenes present in the mixture was determined by comparing the melting point of its diacetamino derivative with the melting points of known mixtures of the diacetamino derivatives of *t*-amylbenzene and 2-phenylpentane (Curve 1).

Experimental Part

Preparation of Methylcyclobutane.—This compound was prepared by debrominating[4] pentaerythrityl bromide[5] with zinc dust. A mixture of methylcyclobutene and methylenecyclobutane[6] was obtained having a boiling point of 40–42.5° at 736 mm. The yield was 65%.

Reaction of Methylcyclobutene and Methylenecyclobutane with Benzene.—The apparatus consisted of a 200-cc. three-necked flask, equipped with a mercury-sealed stirrer, a water-jacketed dropping funnel, and a reflux condenser. The flask was immersed in ice water. Thirty grams of 96% sulfuric acid and 35 g. (0.45 mole) of benzene were placed in the flask and cooled to 4°. A mixture consisting of 25 g. (0.37 mole) of methylenecyclobutane and methylcyclobutene and 35 g. (0.45 mole) of benzene was added during one hour. Two layers were formed: acid layer, 31.3 g., and hydrocarbon layer, 93.5 g. The latter was washed and dried. It was stable toward a 2% potassium permanganate solution, which indicates the absence of olefins. The combined product of three experiments was distilled over metallic sodium.

The benzene was distilled at atmospheric pressure and the methylcyclobutylated benzene under 8 mm. pressure. The following fractions were separated: (1) b. p. 69° at 8 mm., 40 wt. %; (2) 125–143° at 8 mm., 49%; (3) 155–182° at 8 mm., 11%.

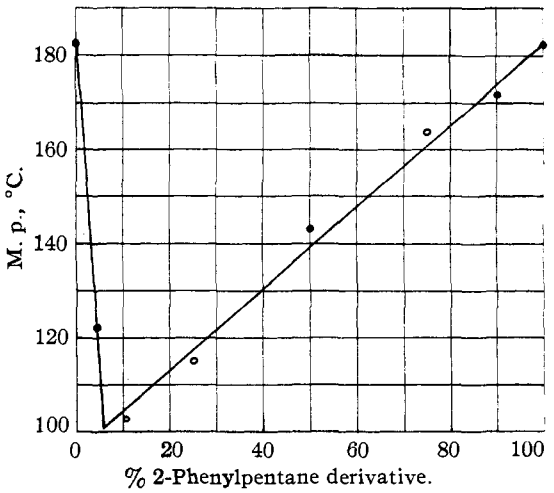


Fig. 1.—Melting point curve for mixtures of the diacetamino derivatives of 2-phenylpentane and *t*-amylbenzene.

On the basis of the distillation it was computed that the reaction mixture consists of

50 Moles mono-methylcyclobutylbenzene
45 Moles di-methylcyclobutylbenzene
5 Moles tri-methylcyclobutylbenzene

The following products were isolated and analyzed.

Fraction 1 consists of 1-methyl-1-phenylcyclobutane, b. p. 69° at 8 mm.; boiling point determined by Cottrell method;[7] 208.6° at 760 mm., dt/dp (760–740 mm.) = 0.05°/mm.; $d^{20}_{vac.}$ 0.9192; $d^{40}_{vac.}$ 0.9044; $-dD/dt$ = 0.00074; $n^{20}D$ 1.5132.

Anal. Calcd. for $C_{11}H_{14}$: C, 90.18; H, 9.82. Found: C, 89.94; H, 9.83.

Monoacetamino derivative[8] (1[1]-methyl-1-cyclobutyl-4-acetaminobenzene), melting point 144°.

Anal. Calcd. for $C_{13}H_{17}O$: C, 76.79; H, 8.43; N, 6.89. Found: C, 76.75; H, 8.32; N, 6.62.

Diacetamino derivative (1[1]-methyl-1-cyclobutyl-2,4-diacetaminobenzene).—Melting point 202°.

Anal. Calcd. for $C_{15}H_{20}O_2N_2$: N, 10.77. Found: N, 10.97.

Fraction 2 was redistilled under 6 mm. pressure. The major part of the product boiled at 124–128° and had $n^{20}D$ 1.5194–1.5245, corresponding to di-(1[1]-methylcyclobutyl)-benzene. Cut b. p. 123–125° at 6 mm., $n^{20}D$ 1.5203, $d^{20}_{vac.}$ 0.9344, $d^{40}_{vac.}$ 0.9198.

Anal. Calcd. for $C_{16}H_{22}$: C, 89.35; H, 10.63. Found: C, 89.48; H, 10.43.

This product crystallizes in ice. A solid was separated which after repeated crystallizations had m. p. 34° and by oxidation was proved to correspond to 1,4-di-(1[1]-methylcyclobutyl)-benzene.

(4) Rave and Tollens, *Ann.*, **276**, 61 (1893); Gustavson, *J. prakt. Chem.*, [2] **54**, 98 (1896).

(5) H. B. Schurink, "Organic Syntheses," Vol. 17, p. 73.

(6) Philipov, *J. prakt. Chem.*, **93**, 102 (1916).

(7) Cottrell, THIS JOURNAL, **41**, 721 (1919); Bruun and Hicks-Bruun, *Bur. Standards J. Research*, **6**, 871 (1931).

(8) Ipatieff and Schmerling, THIS JOURNAL, **59**, 1056 (1937); **60**, 1476 (1938).

Anal. Calcd. for $C_{16}H_{22}$: C, 89.35; H, 10.65. Found: C, 89.51; H, 10.52.

Oxidation.—Seven-tenths gram of the product of b. p. 124–128° at 6 mm. was heated at 160° for two hours in a 60-cc. sealed tube with 12 cc. of 77% nitric acid and 24 cc. of water, according to the procedure recently described.[9] Terephthalic acid was obtained (40% yield). The dimethyl ester of the acid had a melting point of 140° and showed no depression in melting point when mixed with an authentic sample.

Anal. Calcd. for $C_{10}H_{10}O_4$: C, 61.83; H, 5.19. Found: C, 61.60; H, 5.13.

Fraction 3.—B. p. 155–182° under 8 mm., $n^{20}D$ 1.5342.

Anal. Calcd. for $C_{21}H_{30}$: C, 89.29; H, 10.71. Found: C, 89.31; H, 10.42.

Preparation of 1-Methyl-1-cyclohexylcyclobutane.—Nine grams of 1-methyl-1-phenylcyclobutane was dissolved in 10 cc. of *n*-pentane and hydrogenated in a 125-cc. autoclave in the presence of nickel–kieselguhr catalyst[10] at 65° and under the initial hydrogen pressure of 100 atmospheres. The hydrogenated product did not react with nitrating mixture, which indicates the absence of an aromatic ring. The hydrogenated product distilled at 72–73° at 9 mm., 201.5° at 760 mm. dt/dp (752–739 mm.) = 0.08°/mm.; $n^{20}D$ 1.4662; d^{20}_4 0.8595.

Anal. Calcd. for $C_{11}H_{20}$ (1-methyl-1-cyclohexylcyclobutane): C, 86.75; H, 13.25. Found: C, 86.56; H, 13.45.

Dehydrogenation.—1-Methyl-1-cyclohexylcyclobutane was passed over platinized aluminum oxide at 250°. Details have been given in another paper.[11] Aromatic hydrocarbons were obtained distilling at 187 to 192° at 741 mm. and having $n^{20}D$ 1.4861.

A diacetamino derivative[8] was prepared which melted at 144–145°. It consisted of equimolal proportions of *t*-amylbenzene and 2-phenylpentane. This was proved by preparing a melting point curve of the two amylbenzenes and by taking a mixed melting point of the unknown with a mixture of the authentic diacetamino derivatives of the amylbenzenes.

Acknowledgment.—The authors wish to express their thanks to Mr. M. Savoyias for the assistance which he rendered in the laboratory operations.

Summary

A mixture consisting of methylcyclobutene and methylenecyclobutane reacts with benzene in the presence of sulfuric acid to yield: (a) 1-methyl-1-phenylcyclobutane, characterized by solid mono- and diacetamino derivatives; (b) *p*-di-(1[1]-methylcyclobutyl)-benzene, isolated as a crystalline compound; and (c) tri-(1[1]-methylcyclobutyl)-benzene.

Hydrogenation of 1-methyl-1-phenylcyclobutane yielded 1-methyl-1-cyclohexylcyclobutane. The latter on dehydrogenation decomposed into *t*-amylbenzene and 2-phenylpentane.

The cyclobutyl ring becomes very stable toward sulfuric acid or nitrating mixture when a phenyl group is attached to it.

RIVERSIDE, ILLINOIS RECEIVED OCTOBER 5, 1939

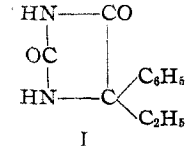
(9) Pines, Grosse and Ipatieff, THIS JOURNAL, **61**, 641 (1939).
(10) Ipatieff and Corson, *Ind. Eng. Chem.*, **30**, 1039 (1938).
(11) Pines and Ipatieff, THIS JOURNAL, **61**, 1077 (1939).

[CONTRIBUTION NO. 169 FROM THE DEPARTMENT OF CHEMISTRY AND CHEMICAL ENGINEERING, THE UNIVERSITY OF TEXAS]

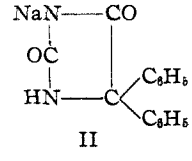
5-[α-(*s*-Butoxy)]-ethyl-5-alkyl Hydantoins

BY ROBERT J. SPEER AND HENRY R. HENZE

During the past few years in this Laboratory considerable attention has been given to the synthesis of hydantoins, a few of which have been shown to possess sufficient physiological activity to warrant continued research in this field. Previous papers of this series have reported extended use of Bucherer's[1] method for the production of substituted hydantoins by interaction of an aqueous alcoholic solution of potassium cyanide and ammonium carbonate with appropriate ketones. The latter have included examples of alkoxymethyl alkyl (or aryl) ketones, phenoxymethyl alkyl (or aryl) ketones, 1,3-dichloroisopropoxyethyl alkyl (or aryl) ketones, dialkylaminoacetones, alkyl nitroaryl ketones, and β-chloroethoxyalkyl alkyl ketones.[2] Although, as yet, but two 5,5-disubstituted hydantoins, namely, Nirvanol (I)[3] and Dilantin (II),[4] have found actual clinical use,



I



II

the hydantoin nucleus offers potentiality as an innocuous heterocycle to which may be attached

(1) Bucherer and Lieb, *J. prakt. Chem.*, [2] **141**, 5 (1934).
(2) Preceding paper in this series, Lingo with Henze, THIS JOURNAL, **61**, 1574 (1939).
(3) Swiss Patent 72,561 (1916).
(4) Putnam and Meritt, *Science*, **85**, 526 (1937).