mixed with 1250 ml. of halogen-free dioxane, was accomplished in a 20-l. autoclave at 220–240° and 2800 p.s.i. hydrogen pressure in the presence of copper chromite catalyst (10% by wt.). Vacuum distillation of the product in 3-ft. columns packed with Berl saddles gave 4070 g. (77% yield) of 1,3-diphenyl-2-methylpropane, b.p. 128–132° (5 mm.), $n^{20}D$ 1.5518–1.5567. The hydrocarbon was then fractionated in a 7-ft. glass-helix-packed column to obtain 1260 g. of distillate which had a constant $n^{20}D$ 1.5519. Upon refractionation of the distillate through a 6-ft. Podbielniak column, 500 ml. of 1,3-diphenyl-2-methylpropane was obtained which, when percolated through silica gel, had the properties listed in Table I.

The hydrogenolyses of the ethyl- and propylcarbinols under similar reaction conditions were relatively unsuccessful. The products were found to contain unconverted carbinol, low-index material indicative of ring attack, and relatively low yields of the respective hydrocarbons. Yields of the 1,3-diphenyl-2-alkylpropane were: ethyl-, 39%; propyl-, 22%.

1,3-Dicyclohexyl-2-methylpropane.—A quantity (1212 g., 5.8 moles) of 1,3-diphenyl-2-methylpropene, dissolved in an equal volume of methylcyclohexane was hydrogenated over U.O.P. nickel catalyst (20% by wt.) at 100–150° and 1800 p.s.i. hydrogen pressure. The product was fractionated *in vacuo* in a 7-ft. glass-helix-packed column and 1220 g. (95% yield) of 1,3-dicyclohexyl-2-methylpropane was obtained, b.p. 141–143° (9 mm.), $n^{20}D$ 1.4735–1.4756. This hydrocarbon was then fractionated in a 6-ft. Podbielniak column to give a quantity of 850 g. which had a constant $n^{20}D$ 1.4755. The 1,3-dicyclohexyl-2-methylpropane was percolated through silica gel and 500 ml. of the hydrocarbon, which had the physical properties listed in Table I, was obtained.

1,3-Diphenyl-2-ethylpropane.—The hydrogenation of 1,3-diphenyl-2-ethylpropene (1883 g., 8.5 moles) was carried out over copper chromite catalyst (10%) at 220–240° and at 2500 p.s.i. hydrogen pressure. Vacuum distillation of the product produced 1565 g. (82% yield) of 1,3-diphenyl-2-ethylpropane, b.p. 153–167° (11 mm.), $n^{20}D$ 1.5495–1.5520. Fractionation of the hydrocarbon in a 6-ft. Podbielniak column gave 798 g. of the 1,3-diphenyl-2-ethylpropane which had the physical properties listed in Table I. The infrared spectrum of the hydrocarbon showed no absorption characteristic of the parent carbinol.

1,3-Dicyclohexyl-2-ethylpropane.—Total reduction of 1,3-diphenyl-2-ethylpropane (1235 g., 5.5 moles) with hydrogen in the presence of U.O.P. nickel catalyst was carried out at 160–200° and 1750 p.s.i. Vacuum distillation of the product gave 1225 g. (94% yield) of 1,3-dicyclohexyl-2-ethylpropane, b.p. 122–126° (2 mm.), and constant $n^{20}D$ 1.4771. Refractionation of the saturated hydrocarbon in a 6-ft. Podbielniak column produced 943 g. of the compound which had a constant $n^{20}D$ 1.4772 and constant d^{20} 0.8749. Examination of the infrared spectrum of the dicyclohexyl hydrocarbon showed that the maximum concentration of the parent aromatic hydrocarbon that could be present was 0.1%.

1,3-Diphenyl-2-propylpropane.—A portion of the 1,3-diphenyl-2-propylpropene (1560 g., 6.6 moles) with 200 ml. of methylcyclohexane as solvent, was hydrogenated over copper chromite catalyst (15% wt.) at 210–250° and 2500 p.s.i. After the solvent was removed by distillation at atmospheric pressure the product was vacuum distilled to obtain 1150 g. (74% yield) of 1,3-diphenyl-2-propylpropane, b.p. 144–154° (2 mm.) and $n^{20}D$ 1.5406–1.5421. Refractionation of the 1,3-diphenyl-2-propylpropane in a 6-ft. Podbielniak column produced 870 g. of the hydrocarbon, which had constant $n^{20}D$ 1.5422 and d^{20} 0.9534–0.9535. The infrared spectrum indicated that the hydrocarbon was not contaminated by unreacted carbinol.

1,3-Dicyclohexyl-2-propylpropane.—Another portion of the 1,3-diphenyl-2-propylpropene (1400 g., 5.9 moles) was totally reduced by hydrogen in the presence of U.O.P. nickel (9% by wt.) at 125–200° and 2500 p.s.i. Vacuum distillation of the product gave 1400 g. (94% yield) of 1,3-dicyclohexyl-2-propylpropane, b.p. 150–152° (2 mm.) and $n^{20}D$ 1.4761–1.4762. The hydrocarbon was then fractionated in a 6-ft. Podbielniak column to obtain 1035 g. of 1,3-dicyclohexyl-2-propylpropane, $n^{20}D$ 1.4763 and d^{20} 0.8718. Examination of the infrared spectrum of the dicyclohexyl hydrocarbon showed that the concentration of the parent aromatic hydrocarbon could not exceed 0.1%.

CLEVELAND, OHIO

[CONTRIBUTION FROM THE FULMER CHEMICAL LABORATORY, THE STATE COLLEGE OF WASHINGTON]

Cortical Steroid Analogs. I. Acetylcarbinols Obtained by the Hydration of Ethynylcarbinols[1]

BY GARDNER W. STACY AND RICHARD A. MIKULEC[2]

RECEIVED AUGUST 31, 1953

A convenient procedure has been developed for the hydration of 1-ethynylcyclopentanol and 1-ethynylcyclohexanol, respectively, to yield the corresponding acetylcarbinols (α-ketols) in about 70% yield. The products obtained were of a high degree of purity, being free of any perceptible amount of isomeric α-ketol formed by ring enlargement. This has been established by periodic acid oxidation of selected fractions of these products to give cyclopentanone and cyclohexanone, respectively, in excellent yield, isolated as their 2,4-dinitrophenylhydrazone derivatives. Further confirmation of structure was obtained by reduction of the α-ketols to glycols and subsequent cleavage with lead tetraacetate to form acetaldehyde and the corresponding alicyclic ketone. 1-Acetylcyclopentanol was also converted by means of the haloform reaction to 1-hydroxycyclohexanecarboxylic acid. In the course of these studies, a good method for the preparation of 1-ethynylcyclopentanol also has been developed.

An approach to the synthesis of cortical steroid analogs, involving elements of structure common to the D-ring of cortisone, previously has been reported.[3] This method involves the conversion of an alicyclic ketone to an ethynylcarbinol followed by hydration in an acidic mercuric sulfate medium to yield an α-ketol.

In parallel work in the steroid series, it had been previously observed that compounds having ethynyl and hydroxyl groups in the 17-position suffer rearrangement on attempted hydration to give an unanticipated D-homosteroid.[4] To obtain the unrearranged, acetylcarbinol structure, it was necessary to resort to modified conditions[5]; however, the yields were not generally good unless the 17-hydroxyl group had been acetylated prior to hydra-

(1) Presented in part before the Division of Organic Chemistry at the 123rd Meeting of the American Chemical Society, Los Angeles, Calif., March 16, 1953.

(2) In part abstracted from a thesis submitted by Richard A. Mikulec in partial fulfillment of the requirements for the Degree of Master of Science, State College of Washington, June, 1953.

(3) G. W. Stacy and C. A. Hainley, THIS JOURNAL, **73**, 5911 (1951).

(4) (a) L. Ruzicka, *et al.*, *Helv. Chim. Acta*, **21**, 1760 (1938); **22**, 626 (1939); (b) H. E. Stavely, THIS JOURNAL, **61**, 79 (1939); (c) a more detailed summary of previous work relating to this subject has recently been presented by R. B. Turner, *ibid.*, **75**, 3484 (1953).

(5) H. E. Stavely, *ibid.*, **62**, 489 (1940).

tion.[6] In view of these circumstances, it was of critical interest in the present case to establish the structure of the product obtained on hydration as an acetylcarbinol and to demonstrate that it was free of any isomeric α-ketol produced by rearrangement.

The hydration product, believed to be 1-acetylcyclopentanol(II), was prepared by a more convenient procedure than that previously reported.[3] The present method, which employed a direct addition of the ethynylcarbinol, as represented by I, to the hydrating mixture at 60°, was arrived at after numerous experiments involving varying conditions of temperature and acid concentration. The crude product was fractionally distilled, and the fractions having a constant boiling point and refractive index consistently represented yields of about 70%. Representative fractions from this material were treated with periodic acid. In each case the material smoothly cleaved to cyclopentanone, which was isolated as a 2,4-dinitrophenylhydrazone in over-all yields ranging from 82–85% after recrystallization. Control runs in which pure cyclopentanone was treated under similar conditions gave a recovery of cyclopentanone as a 2,4-dinitrophenylhydrazone in similar yield. It is, therefore, indicated that the product obtained in the yield claimed by the present hydration procedure is of the structure assigned and in a high degree of purity free of any significant amount of α-ketol formed by rearrangement. It is to be noted that lead tetraacetate was initially employed in several degradation experiments of the type just described, but it did not prove to be as effective as periodic acid and gave cyclopentanone in low yield.

Further work on the confirmation of the structure (II) also was carried out. It was characterized by conversion to semicarbazone and 3,5-dinitrobenzoate derivatives and by its infrared absorption spectrum, which exhibited bands consistent with the carbonyl and tertiary hydroxyl functions. It readily could be reduced to a glycol III, which was characterized in a manner similar to II. In addition, this glycol could be cleaved by lead tetraacetate to give the anticipated products, acetaldehyde and cyclopentanone, isolated as 2,4-dinitrophenylhydrazones in good yield. Also, II was caused to undergo the haloform reaction to give 1-hydroxycyclopentanecarboxylic acid (V). For further confirmation most of the work described was carried out in parallel with the corresponding cyclohexane derivatives. In none of these experiments in either series was there any evidence revealed which indicated the presence of isomeric ketols formed by rearrangement.

The intermediate 1-ethynylcyclopentanol (I) was prepared by ethynylation of cyclopentanone. Although this is a well known reaction, it has not previously been applied very successfully to cyclopentanone. Of interest is the fact that the yield of I obtained is only 13% under conditions identical with those which give a result of about 70% in the case of cyclohexanone.[7] Although somewhat better, the procedure reported by Backer and van der Bij[8] was also none too satisfactory. In these procedures the main by-product isolated was cyclopentylidene-2-cyclopentanone, suggesting that an increased concentration of sodium acetylide relative to that of cyclopentanone might result in improvement. In accordance with this, when 1.25 equivalents of sodium acetylide with one equivalent of cyclopentanone were employed, I was obtained in a 62% yield. Further increases in the quantity of sodium acetylide caused no significant improvement in yield.

This two-step sequence, as described, involving ethynylation of an alicyclic carbonyl followed by hydration of the intermediate ethynylcarbinol,[9] constitutes a superior approach to the elaboration of the cortisone side chain in the preparation of analogs.[10]

Experimental[11]

1-Ethynylcyclopentanol (I).—In a 1-l. three-necked flask, fitted with a mechanical stirrer, a gas inlet tube and a dropping funnel and containing a vent for escape of the acetylene being introduced, was placed 750 ml. of liquid ammonia (this preparation should be carried out in an efficient hood). To the ammonia were added 0.25 g. of ferric nitrate nonahydrate and 0.50 g. of sodium. The solution was stirred for one and three-quarters hours during which time the initial blue color was replaced by a dark gray coloration. Thirty-four grams (1.5 gram atoms with the amount used above) of sodium was then added in small pieces during a period of five minutes. The volume of the reaction mixture was brought back to its original level with additional liquid ammonia, and stirring was continued for 25 minutes or until the solution became black. Acetylene, purified by passing through concentrated sulfuric acid, an empty bottle serving as a safety trap, 5% sodium hydroxide, and a calcium chloride drying tower, was passed through the reaction mixture, as it was stirred, for a period of 4.5 hours, during which time it changed from black to a light blue and back to black. After completion of this period which was required for the

(6) C. W. Shoppee and D. A. Prins, *Helv. Chim. Acta*, **26**, 185 (1943).

(7) J. H. Saunders, *Org. Syntheses*, **29**, 47 (1949).

(8) H. J. Backer and J. R. van der Bij, *Rec. trav. chim.*, **62**, 561 (1943).

(9) Some compounds of this type have been reported recently as prepared in part by a similar synthetic approach: D. Papa, H. F. Ginsberg and F. J. Villani, Abstracts of Papers, Division of Medicinal Chemistry, 122nd Meeting of the American Chemical Society, Atlantic City, N. J., 4L, September, 1952.

(10) Compare the three-step sequence of J. D. Billimoria and N. F. MacLagen, *J. Chem. Soc.*, 3067 (1951). ADDED IN PROOF.—The use of the two-step sequence, as applied to 2-methylcyclohexanone, just has been reported independently by J. D. Billimoria, *ibid.*, 2626 (1953). A novel procedure for the hydration of ethynylcarbinols using a resin, impregnated with mercuric ion, also has been published recently by M. S. Newman, THIS JOURNAL, **75**, 4740 (1953).

(11) All melting points are corrected and boiling points are uncorrected. The microanalytical work was performed by the Galbraith Laboratories, Knoxville, Tennessee.

formation of the sodium acetylide solution, 84.0 g. (1.0 mole) of cyclopentanone was added through the dropping funnel (one hour required). The flow of acetylene was decreased somewhat, and vigorous stirring was continued over a seven-hour period. The flow of acetylene was then finally stopped, but the mixture was stirred for an additional eight hours. During these operations the volume was replenished periodically with liquid ammonia to maintain its original level.

After the reaction period, as described, had been completed, the ammonia was allowed to evaporate. To the solid, black residue was then added in small portions 350 g. of a slurry of ice and water. To this was added portionwise a solution of 53.5 g. of ammonium chloride in 150 ml. of water, and the mixture was stirred until the solid was dissolved. The organic layer was taken up in 200 ml. of ether and separated. The aqueous layer was extracted with four 100-ml. portions of ether. The ether extracts were combined and dried over anhydrous magnesium sulfate. The solvent was removed, and the residue was distilled under reduced pressure. A forerun of 5.1 g. and 72.9 g. (66%) of 1-ethynylcyclopentanol (I), b.p. 60–65° (15 mm.), $n^{20}D$ 1.4741, were obtained.[12]

If only one equivalent of sodium acetylide is employed, I is obtained in only a 26% yield; however, a quarter equivalent of sodium acetylide in excess appears sufficient to ensure a satisfactory result (62%).

A **3,5-dinitrobenzoate** of I was prepared by heating under reflux equimolar quantities of I and 3,5-dinitrobenzoyl chloride in a mixture of anhydrous pyridine, benzene and petroleum ether (b.p. 60–90°) for 12 hours. Recrystallization from 95% ethanol gave small, white plates, m.p. 134.5–135.5°.

Anal. Calcd. for $C_{14}H_{12}N_2O_6$: C, 55.26; H, 3.98; N, 9.21. Found: C, 55.20; H, 3.88; N, 9.25.

1-**Acetylcyclopentanol** (II).—In a 1-l. three-necked flask, equipped with a mechanical stirrer, dropping funnel, condenser and thermometer, were placed a solution of 5.0 g. of mercuric oxide in 190 ml. of water and 8 ml. of concentrated sulfuric acid. The solution was stirred and heated to 60°, and 44.0 g. (0.40 mole) of I was added through the dropping funnel during a period of 90 minutes. The mixture was stirred at this temperature for ten minutes longer and then allowed to cool to room temperature. The organic layer was dissolved in 150 ml. of ether and separated. The aqueous layer was continuously extracted with 150 ml. of ether for 14 hours. After being dried, the ether extracts were combined, the solvent removed and the residue fractionally distilled through a 15-cm. column packed with glass helices. The distillate was collected in a number of fractions, and those having a constant boiling point and refractive index amounted to 35.6 g. (69%); b.p. 75.8–76.4° (10 mm.), $n^{25}D$ 1.4619, d^{25}_4 1.0378.

Anal. Calcd. for $C_7H_{12}O_2$: C, 65.59; H, 9.44; M_D, 33.87. Found: C, 65.67; H, 9.43; M_D, 33.95.

A **semicarbazone** was prepared from 1.08 g. of II employing aqueous sodium acetate.[13] There was obtained 1.34 g. (85%), m.p. 180.3–181.4°; recrystallization from 95% ethanol afforded 1.08 g. (69% over-all), m.p. 181–182°.[14]

Anal. Calcd. for $C_8H_{15}N_3O_2$: C, 51.87; H, 8.16; N, 22.69. Found: C, 51.99; H, 8.05; N, 22.85.

Several other representative samples of II having $n^{25}D$ 1.4619, which was identical with that used in the periodic acid cleavage experiments to be described subsequently, all consistently gave this same semicarbazone.

A **3,5-dinitrobenzoate** of II also was prepared and recrystallized from 95% ethanol to give fine, white needles, m.p. 134.5–135.5°.

Anal. Calcd. for $C_{14}H_{14}N_2O_7$: C, 52.17; H, 4.38; N, 8.69. Found: C, 52.14; H, 4.35; N, 8.60.

1-**Acetylcyclohexanol** (VI).—The hydration of 49.7 g. (0.40 mole) of 1-ethynylcyclohexanol was carried out by the procedure given above for II. On distillation there were obtained a forerun of 8.39 g. and 39.8 g. (70%) of 1-acetylcyclohexanol; b.p. 92–94° (15 mm.), $n^{25}D$ 1.4670,[15] d^{25}_4 1.0248; M_D calcd. 38.49, found 38.50.

A **3,5-dinitrobenzoate** derivative was recrystallized from 95% ethanol to give fine, white needles, m.p. 132.5–133.5°.

Anal. Calcd. for $C_{15}H_{16}N_2O_7$: C, 53.57; H, 4.80; N, 8.33. Found: C, 53.60; H, 4.65; N, 8.39.

Oxidation of Ketols with Periodic Acid.—Approximately 0.002 mole of the ketol was dissolved in 40 ml. of water. To this was added two equivalents of 0.54 *M* periodic acid solution. The mixture was allowed to stand at room temperature for 15 minutes with occasional swirling. The reaction mixture was then made neutral with saturated barium hydroxide solution and centrifuged, the resulting supernatant being decanted through a fine, frittered-glass crucible. The precipitate was washed with 40 ml. of hot ethanol, which was also decanted through the crucible. The combined filtrates were added dropwise with stirring to 200 ml. of 2 *N* hydrochloric acid saturated with 2,4-dinitrophenylhydrazine.[16] After being diluted with 50 ml. of 2 *N* hydrochloric acid, the mixture was allowed to stand for two hours at room temperature. The precipitate of the 2,4-dinitrophenylhydrazone was then filtered onto a coarse, frittered-glass crucible, washed with 100 ml. of 2 *N* hydrochloric acid and then distilled water until the washings gave a negative test for chloride with silver nitrate. The precipitates were dried to constant weight at 95°.

The crude cyclopentanone 2,4-dinitrophenylhydrazones, secured by the above procedure from several representative fractions of II, were obtained in over-all yields of 90–91%, representative m.p. 141.6–144.1°.[17] Admixture with an authentic sample showed no depression, m.p. 142.6–145.4°. Recrystallization from ethanol detracted from the over-all yield only slightly, 82–85%, m.p. 145–146°.

When pure cyclopentanone was treated under conditions similar to II with one equivalent of both periodic acid and iodic acid, it was possible to recover 87% as a crude 2,4-dinitrophenylhydrazone or 79% as the recrystallized product. Cyclopentanone, which had not been treated with periodic acid, was converted to its 2,4-dinitrophenylhydrazone in quantitative yield.

1-Acetylcyclohexanol (VI) treated with periodic acid in an exactly analogous manner afforded a 90% yield of cyclohexanone 2,4-dinitrophenylhydrazone, m.p. 157.3–158.6°[18]; admixture with an authentic sample caused no depression, m.p. 158.6–160.7°. After one recrystallization from ethanol, the over-all yield was 83%, m.p. 159.6–161°. Pure cyclohexanone, after treatment with periodic acid–iodic acid mixture, was recovered in approximately the same yield as in the oxidation of VI.

1-(1-**Hydroxyethyl**)-**cyclopentanol** (III).—Low-pressure hydrogenation of a solution of 12.8 g. (0.10 mole) of II in 25 ml. of ethanol with 0.05 g. of platinum oxide as catalyst was complete in four hours and required 97% of 0.1 molar equivalent of hydrogen. The catalyst was separated by filtration, the solvent removed, and the residue fractionally distilled under reduced pressure through a 15-cm. column packed with glass helices. The glycol amounted to 8.49 g. (65%); b.p. 104–105° (10 mm.), $n^{25}D$ 1.4780, d^{25}_4 1.0516.

Anal. Calcd. for $C_7H_{14}O_2$: C, 64.58; H, 10.84; M_D, 35.38. Found: C, 64.41; H, 10.68; M_D, 35.03.

A **bis-3,5-dinitrobenzoate** resulted on heating III under reflux with an excess of the acid chloride in pyridine solution for 11 hours. After working up the mixture in the usual way and recrystallizing the crude product from aqueous acetone, there were obtained small, white plates, m.p. 157.5–158.5°.

Anal. Calcd. for $C_{21}H_{18}N_4O_{12}$: C, 48.65; H, 3.50; N, 10.81. Found: C, 48.48; H, 3.53; N, 10.98.

1-(1-**Hydroxyethyl**)-**cyclohexanol** (VII).—Low-pressure hydrogenation of a solution of 14.2 g. (0.10 mole) of VI in 25 ml. of ethanol with 0.10 g. of platinum oxide as catalyst was complete in four hours and required a 0.1 molar equivalent of hydrogen. The reaction mixture was worked up as

(12) P. S. Pinkney and C. S. Marvel, THIS JOURNAL, **59**, 2669 (1937), reported b.p. 65–65.5° (16 mm.), $n^{20}D$ 1.4741.

(13) R. L. Shriner and R. C. Fuson, "The Systematic Identification of Organic Compounds," John Wiley and Sons, Inc., New York, N. Y., 1948, p. 170.

(14) Billimoria and MacLagen (ref. 10) report m.p. 206–208° (dec.).

(15) Reported previously (ref. 3); b.p. 90–93° (15 mm.), $n^{25}D$ 1.4673.

(16) Determination of ketones as 2,4-dinitrophenylhydrazones is based on the procedure of H. A. Iddles, *et al.*, *Ind. Eng. Chem., Anal. Ed.*, **11**, 102 (1939).

(17) H. H. Strain, THIS JOURNAL, **57**, 758 (1935), reported m.p. 145.5–146.5°.

(18) C. F. H. Allen, *ibid.*, **52**, 2955 (1930), reported m.p. 160°.

in the above procedure. The glycol amounted to 9.64 g. (67%); b.p. 120–121° (10 mm.), $n^{25}D$ 1.4843, d^{25}_4 1.0422.

Anal. Calcd. for $C_8H_{16}O_2$: C, 66.62; H, 11.18; M_D, 40.00. Found: C, 66.63; H, 11.09; M_D, 39.61.

A **mono-3,5-dinitrobenzoate** was prepared in a manner similar to that of I, above. This substance was recrystallized from 95% ethanol to give fine, white needles, m.p. 122.5–123.5°.

Anal. Calcd. for $C_{13}H_{18}N_2O_7$: C, 53.25; H, 5.36; N, 8.28. Found: C, 53.46; H, 5.33; N, 8.35.

Oxidation of Glycols with Lead Tetraacetate.—A sample of 0.52 g. (0.004 mole) of III dissolved in 20 ml. of glacial acetic acid was dropped upon dry lead tetraacetate in an apparatus so arranged that a slow stream of dry air could be passed over the mixture to sweep out acetaldehyde[19] (anticipated as one of the products) into a receiver containing 300 ml. of 2 *N* hydrochloric acid saturated with 2,4-dinitrophenylhydrazine. The removal of acetaldehyde was completed by heating the mixture at 60° for one-half hour, while the flow of dry air was continued through the apparatus.

The crude acetaldehyde 2,4-dinitrophenylhydrazone was filtered off and air-dried; 0.53 g. (68%), m.p. 146–149°.[20] When admixed with an authentic sample of acetaldehyde 2,4-dinitrophenylhydrazone, the melting point showed no depression, m.p. 146–150°. After one recrystallization, from dilute ethanol, the product amounted to 0.45 g. and melted at 153.5–154°.

The mixture left in the reaction flask, after the oxidation had been completed, was distilled to dryness under reduced pressure. The distillate was added to 200 ml. of 2 *N* hydrochloric acid solution saturated with 2,4-dinitrophenylhydrazine. The crude cyclopentanone 2,4-dinitrophenylhydrazone which formed was removed by filtration and air-dried and amounted to 0.76 g. (72%), m.p. 142.5–145°.[17] When admixed with the 2,4-dinitrophenylhydrazone prepared from an authentic sample of cyclopentanone, the melting point showed no depression, m.p. 143–146°. After one recrystallization from dilute ethanol the product amounted to 0.59 g., m.p. 144.5–145.5°.

The glycol of the cyclohexane series (VII) was treated with lead tetraacetate by identically the same procedure. Crude acetaldehyde 2,4-dinitrophenylhydrazone was obtained in a 70% yield and cyclohexanone 2,4-dinitrophenylhydrazone in a 74% yield.

Reaction of 1-Acetylcyclopentanol (II) with Sodium Hypobromite.—To a solution of 8.4 g. of sodium hydroxide in 70 ml. of water at 0° was added 12.0 g. of bromine. To this solution at 0° was slowly added 2.62 g. (0.020 mole) of II. The mixture was stirred in an ice-bath for 30 minutes and then at room temperature for three hours. The bromoform was separated by means of a separatory funnel and the aqueous layer carefully acidified with 10 ml. of concentrated sulfuric acid. The solution was extracted with several portions of ether; the combined extracts were then washed with several portions of saturated sodium bisulfide solution and dried over anhydrous magnesium sulfate. The solvent was removed and the residue recrystallized from toluene–petroleum ether (b.p. 35–50°) to give 1.15 g. (43%) of 1-hydroxycyclopentanecarboxylic acid (V), m.p. 102–103.5°.[21] On admixture with an authentic specimen prepared from the cyanohydrin of cyclopentanone, no depression was observed, m.p. 104–105°.

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We are indebted to Dr. Edward L. Wagner and Mr. David E. Little (deceased) for determination of the infrared adsorption spectra.

(19) The portion of the procedure dealing with the determination of acetaldehyde is adapted from that of R. C. Hockett, *et al.*, THIS JOURNAL, **68**, 922 (1946).

(20) One of the melting points reported for acetaldehyde 2,4-dinitrophenylhydrazone is 148°; another form is reported to melt at 157°—W. M. D. Bryant, *ibid.*, **60**, 2814 (1938).

(21) O. Wallach, *Ann.*, **414**, 296 (311) (1918), reported m.p. 103–104°.

PULLMAN, WASHINGTON

[CONTRIBUTION FROM THE EASTERN REGIONAL RESEARCH LABORATORY[1]]

Steroidal Sapogenins. XI.[2] Steroidal C-Ring Lactones

BY EDWARD S. ROTHMAN, MONROE E. WALL AND C. ROLAND EDDY

RECEIVED SEPTEMBER 19, 1953

Contrary to reports by other workers we have found that acid-catalyzed perbenzoic acid and peracetic acid oxidation of steroidal C_{12}-ketosapogenins results in oxidative attack on the C-ring with ε-lactone formation. The introduction of oxygen led to only one of the two possible isomeric lactones, *viz.*, the lactone of the 12,13-secospirostane series. The sapogenin side chain was unaffected by the reagent. The bile acid, methyl 3α-carbethoxyoxy-12-ketocholanate, gave similar results, but C_{11}-ketosteroids resisted attack.

Oxidation of steroid carbonyl groups at C_3, C_7, C_{17} and C_{20} by peracids has been reported by various workers.[3–7] On the other hand, the less reactive carbonyl groups at C_{11} and C_{12} are described as inert[8] to this type of reagent. We have found conditions for reaction not only of the C_{12} keto group of methyl 3α-carbethoxyoxy-12-ketocholanate, but also for reaction of the more hindered C_{12} keto group of the sapogenin, hecogenin acetate (5α,22α-spirostan-3β-ol-12-one 3-acetate). Under non-anhydrous reaction conditions using perbenzoic acid or peracetic acid in the presence of a catalytic amount of sulfuric acid and a reaction period of several days, seven-membered-C-ring lactones were obtained in high yield. In this manner the oxidation of hecogenin acetate led to the formation of a single lactonic product

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