enough acetic anhydride to convert the added water to acetic acid.

6. It is more economical to use a slight excess of nitrating agent than to take the equivalent amount and then separate unreacted acetyl-*p*-anisidine from the nitration product.

With the information from these experiments we set up a procedure for nitrating acetyl-*p*-anisidine in acetic acid–acetic anhydride solution with a solution of potassium nitrate, sulfuric acid and water. The procedure gave satisfactory results as a comparison with the results of Mosher, Yanko and Whitmore[6a] shows.

	Equivalents of NO_3^-	Yield, % Based on acetyl-*p*-anisidine	Yield, % Based on NO_3^-
Mosher, Yanko, Whitmore	1.6	85	57
This article	1.09	77	70

A more complete description of our work with full experimental details is available in microfilm.

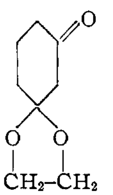
DEPARTMENT OF CHEMISTRY
QUEENS COLLEGE
FLUSHING 67, N. Y.

Reactions of the Monoethylene Ketal of 1,3-Cyclohexanedione

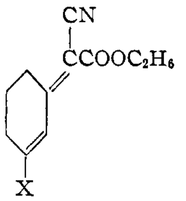
BY MARSHALL W. CRONYN AND GREGOR H. RIESSER

RECEIVED OCTOBER 31, 1952

The reactions of the monoethylene ketal of 1,3-cyclohexanedione[1] (I) have been investigated in more detail in an effort to obtain certain 3-substituted cyclohexanones which could be of value as intermediates in the preparation of 5-substituted morphans.



I



II, X = NH_2
III, X = $NHCH_2C_6H_5$
IV, X = OH
V, X = OCH_2CH_2OH

Reaction of the monoethylene ketal (I) with ethyl cyanoacetate in alcoholic ammonia did not give the expected Guareschi imide,[2] as shown both by its insolubility in dilute alkali and by its elemental analysis, $C_{11}H_{14}N_2O_2$. The analysis and the ultraviolet absorption spectrum indicated that the product, obtained in 82–90% yield, was ethyl α-cyano-3-amino-2-cyclohexene-$\Delta^{1,\alpha}$-acetate (II). Evidence for the structure of II was obtained by hydrolysis to the corresponding enol (IV), whose absorption spectrum was quite similar, and by the independent synthesis of both II and IV.

The enol (V) was synthesized by condensation of the monoethylene ketal (I) with ethyl cyanoacetate in chloroform with acetic acid and ammonium acetate.[3] The crude material obtained by distillation of the Knoevenagel reaction product was a mixture of the enol (V) and the corresponding cyclic ketal.

When the enol ether (V) was treated with alcoholic ammonia there was an immediate reaction and the eneamine (II) was obtained. Thus, under the Guareschi conditions, II must be obtained from the monoethylene ketal (I) by means of a Knoevenagel type reaction followed by opening of the cyclic ketal to the enol ether (V) and 1,6-addition of ammonia with elimination of the ethylene glycol.

As would be expected of a vinylog of an amide, II is a neutral compound, soluble only in concentrated hydrochloric or sulfuric acids; upon immediate dilution the eneamine is recovered unchanged. Refluxing II in either acidic or alkaline solution gives the enol (IV). As a vinylog of an acyl cyanoacetate[4] the enol is acidic enough to be titrated quantitatively to the phenolphthalein end-point.

Extensive hydrolysis of the eneamine (II) in acid solution gave 3-methyl-2-cyclohexene-1-one. This is analogous to the hydrolysis and decarboxylation of diethyl 3-oxo-2-cyclohexene-1-methylmalonate previously reported.[5]

The monoethylene ketal (I) was condensed with cyanoacetic acid in the presence of ammonium acetate[6] and there was obtained, in low yield, the ethylene ketal of 3-oxo-1-cyclohexeneacetonitrile.

A reductive condensation[7] with ethyl cyanoacetate proceeded readily to the ethylene ketal of ethyl 3-oxo-cyclohexaneacetate. Hydrolysis and decarboxylation of this ketal gave 3-oxo-cyclohexaneacetic acid.

Attempted reductive amination of the monoethylene ketal (I) gave no reproducible results.

Experimental[8]

Monoethylene Ketal of 1,3-Cyclohexanedione.—The preparation as described previously[1] was simplified by extraction of the ketal from the benzene solution with 2 *N* sodium metabisulfite. A 35% yield of pure ketal was obtained after saturation with potassium carbonate, extraction with chloroform and distillation.

Ethyl α-Cyano-3-amino-2-cyclohexene-$\Delta^{1,\alpha}$-acetate (II).—A mixture of 31.2 g. (0.2 mole) of the monoethylene ketal of 1,3-cyclohexanedione (I) and 25 g. (0.22 mole) of ethyl cyanoacetate were placed in a citrate bottle with 75 ml. of absolute alcohol saturated at −10° with ammonia (*ca.* 15 g. of ammonia). The solution turned yellow, became warm and after about 30 min. a precipitate separated. After an hour the reaction had subsided and the solution was cooled in ice and filtered. The product was washed with water and air-dried to give 30 to 37 g. (82–90% yield) of yellow crystalline material melting at 230–233° with dec. An analytical sample was prepared by recrystallization from 95% ethanol and from dimethylformamide–water, m.p. 232–233.5° dec.

Anal. Calcd. for $C_{11}H_{14}N_2O_2$: C, 64.06; H, 6.84; N, 13.59; mol. wt., 206. Found: C, 63.97; H, 6.74; N, 13.32; mol. wt., 196.

---

[1] M. W. Cronyn and J. E. Goodrich, THIS JOURNAL, **74**, 3331 (1952).

[2] I. Guareschi, *Gazz. chim. ital.*, **48**, II, 83 (1918).

[3] A. C. Cope and E. M. Hancock, *Org. Syntheses*, **25**, 46 (1945); E. J. Cragoe, C. M. Robb and J. M. Sprague, *J. Org. Chem.*, **15**, 381 (1948).

[4] G. E. K. Branch and M. Calvin, "The Theory of Organic Chemistry," Prentice–Hall, Inc., New York, N. Y., 1941, p. 268.

[5] C. Clemo, W. Cocker and S. Hornsby, *J. Chem. Soc.*, 616 (1946).

[6] D. E. Whyte and A. C. Cope, THIS JOURNAL, **65**, 1999 (1943).

[7] E. R. Alexander and A. C. Cope, *ibid.*, **66**, 886 (1944).

[8] Analyses by the Microanalytical Laboratory of the Department of Chemistry, University of California. The ultraviolet absorption spectra were taken in 95% ethanol using a Beckman model DU spectrophotometer. All melting points are corrected.

Ultraviolet absorption, λ_{max} 226 mμ, log ϵ 4.00 and λ_{max} 381 mμ, log ϵ 4.76 with a minimum at 283 mμ, log ϵ 1.78.

Butyl α-Cyano-3-amino-2-cyclohexene-$\Delta^{1,\alpha}$-acetate.—The *n*-butyl ester was obtained in the same manner, m.p. 142–143° after recrystallization from benzene–ethanol.

Anal. Calcd. for $C_{13}H_{18}N_2O_2$: C, 66.64; H, 7.74. Found: C, 66.65; H, 7.63.

Ethyl α-Cyano-3-(N-benzylamino)-2-cyclohexene-$\Delta^{1,\alpha}$-acetate (III).—When a mixture of the monoketal, ethyl cyanoacetate and benzylamine was allowed to stand at 40° for 6 days, the N-benzyl derivative crystallized upon cooling the solution, m.p. 135–137°. An analytical sample was obtained by two crystallizations from 95% ethanol, m.p. 139–139.5°.

Anal. Calcd. for $C_{18}H_{20}N_2O_2$: C, 72.95; H, 6.80; N, 9.46. Found: C, 72.81; H, 7.07; N, 9.73.

Ultraviolet absorption, λ_{max} 386 mμ, log ϵ 4.80; λ_{max} 227 mμ, log ϵ 4.04.

Ethyl α-Cyano-3-hydroxy-2-cyclohexene-$\Delta^{1,\alpha}$-acetate (IV). a. **By Alkaline Hydrolysis.**—The eneamine ester (II) (2.08 g., 0.01 mole) was heated for 3.5 hr. in 100 ml. of refluxing 1 *N* alcoholic potassium hydroxide. The ammonia evolved was absorbed in 0.1 *N* hydrochloric acid; titration showed 0.93 mole equivalent of ammonia absorbed. A small amount of unreacted starting material was removed by filtration and the solution was concentrated *in vacuo* and acidified. There was obtained 1.4 g. (67%) of the light tan crystalline acid, m.p. 139–141°. An analytical sample was obtained by crystallization from cyclohexane–ethyl acetate, m.p. 142–143.5°; ultraviolet absorption, λ_{max} 343 mμ, log ϵ 4.44.

Anal. Calcd. for $C_{11}H_{13}NO_3$: C, 63.75; H, 6.32; N, 6.76; neut. equiv., 207. Found: C, 64.01; H, 6.37; N, 6.57; neut. equiv., 209.

b. **By Acid Hydrolysis (4.5 Hr.).**—A solution of 4 g. of (II) in 20 ml. of water and 20 ml. of ethanol with 7 ml. of concentrated sulfuric acid was allowed to reflux for 4.5 hr. The solution was filtered, concentrated and diluted with 30 ml. of water. After recrystallization of the product from ethanol there was obtained 1.4 g. of material melting at 139–141° and with no depression in melting point when mixed with a sample obtained by alkaline hydrolysis.

c. **Acid Hydrolysis (24 Hr.).**—A solution of 4 g. of the eneamine ester (II) was heated for 24 hr. in 20 ml. of 50% ethanol and 5 ml. of concentrated sulfuric acid. The alcohol was removed, the solution was diluted with water and it was then extracted with chloroform. From the chloroform there was obtained 0.4 g. of 3-methyl-2-cyclohexene-1-one, b.p. 60–61° at 4 mm., n^{25}D 1.4915. The 2,4-dinitrophenylhydrazone, m.p. 175–177° after crystallization from ethanol–ethyl acetate, gave no depression in m.p. when mixed with the 2,4-dinitrophenylhydrazone of an authentic sample.[1]

Knoevenagel Reaction with the Monoketal (I).—The ketal (7.7 g., 0.05 mole), ethyl cyanoacetate (11.3 g., 0.1 mole), acetic acid (4.8 g.), and 50 ml. of chloroform were heated under a soxhlet extractor containing anhydrous magnesium sulfate in the thimble. One-half gram portions of ammonium acetate were added after 5 min., 1 hr., 3 hr. and 5 hr. After 6 hr. the solution was washed with water and 8% bicarbonate. Removal of the volatile material by distillation *in vacuo* followed by distillation of the residue at 215–230° (3 mm.) gave a solid which was recrystallized from methylcyclohexane–ethyl acetate to give 3.4 g. (27%) of **ethyl α-cyano-3-(β-hydroxyethyl)-2-cyclohexene-$\Delta^{1,\alpha}$-acetate**, m.p. 105–108°. Recrystallization from benzene–petroleum ether gave an analytical sample, m.p. 112–112.5°; ultraviolet absorption, λ_{max} 339 mμ, log ϵ 4.24.

Anal. Calcd. for $C_{12}H_{17}NO_4$: C, 62.03; H, 6.84; N, 5.58. Found: C, 61.74; H, 6.85; N, 5.77.

Fractionation of the product from another experiment starting with 15 g. of the ketal (I) gave 3.2 g. of a fraction, b.p. 174° (0.2 mm.), n^{25}D 1.4901, and a higher boiling fraction, 1.2 g. at 200–210°. The 200–210° fraction solidified immediately upon cooling while the 174° fraction solidified slowly after several weeks.

One gram of the ketal (174° fraction) dissolved in 5 ml. of 95% ethanol and 5 ml. of 6 *N* hydrochloric acid gave upon standing 0.6 g. of light tan solid, m.p. 134–136°. Recrystallization from methylcyclohexane–ethyl acetate gave material melting at 142–143° and unchanged when mixed with the enol (IV). The same procedure applied to the solid (V), gave 0.54 g. of the enol, m.p. 141–142°; a mixed melting point with IV was undepressed.

Reaction of V with Ammonia to Give II.—Five hundred milligrams of crude V dissolved in 10 ml. of methanol and 10 ml. of aqueous ammonia gave, after 15 min., 350 mg. of yellow crystals, m.p. 231–232° with no depression when mixed with a sample of II.

Ethylene Ketal of 3-Oxo-1-cyclohexene-1-acetonitrile.—The monoketal (I) (15.6 g.), cyanoacetic acid (9.5 g.) and ammonium acetate (0.45 g.) were heated in 50 ml. of refluxing benzene under a constant water separator for 2 hr., another portion of 0.15 g. of ammonium acetate was added and the heating was continued for 6 hr. Removal of the solvent and distillation of the residue up to 180° and 1 mm. gave 9.4 g. of crude material which was fractionated to give 4.5 g. (25%) of a light yellow oil, b.p. 122–127° at 2 mm., n^{22}D 1.5002. The 2,4-dinitrophenylhydrazone was recrystallized from ethanol–ethyl acetate to give small red prisms, m.p. 187–188.5°.

Anal. Calcd. for $C_{14}H_{13}N_5O_4$: C, 53.33; H, 4.16; N, 22.23. Found: C, 53.50; H, 3.90; N, 22.45.

Ethylene Ketal of Ethyl α-Cyano-3-oxo-cyclohexane-1-acetate.—A solution of 7.7 g. (0.05 mole) of I and 11.3 g. (0.1 mole) of ethyl cyanoacetate in 20 ml. of absolute ethanol was shaken for 20 hr. under 35 lb. hydrogen pressure with 0.2 g. of 5% palladium-charcoal catalyst.[9] Fractionation of the product gave 7.4 g. (58%) with a b.p. of 151–152° at 0.8 mm. and n^{23}D 1.4722.

Anal. Calcd. for $C_{13}H_{19}NO_4$: C, 61.64; H, 7.56; N, 5.53. Found: C, 61.86; H, 7.64; N, 5.26.

3-Oxo-cyclohexaneacetic Acid.—The crude ketal prepared as described above was hydrolyzed by heating in 30 ml. of acetic acid and 20 ml. of concentrated hydrochloric acid for 16 hr. Crystallization of the crude product from benzene gave 1.3 g. of acid, m.p. 79.5–81° (lit. 81–82°).[10]

---

(9) American Platinum Works, Newark, N. J.

(10) P. D. Bartlett and G. F. Woods, THIS JOURNAL, **62**, 2933 (1940).

DEPARTMENT OF CHEMISTRY AND CHEMICAL ENGINEERING
UNIVERSITY OF CALIFORNIA
BERKELEY 4, CALIFORNIA

Some Ethers of Pentaerythritol and Their Nitrate Esters[1]

BY ROBERT EVANS AND J. A. GALLAGHAN

RECEIVED NOVEMBER 3, 1952

The allylation of pentaerythritol to form a mixture of monoallyl and diallyl ethers as the principal products has been accomplished by a modification of the method of Nichols and Yanovsky[2] for the partial allylation of pentaerythritol.

Experimental

Preparation of Mono- and Diallyl Pentaerythritol Ethers.—A suspension consisting of 273 g. of pentaerythritol and 300 g. of *p*-dioxane was placed in a three-necked flask equipped with a mercury-sealed stirrer, a dropping funnel and a reflux condenser. A mixture of 80 g. of sodium hydroxide and 36 g. of water was slowly added to the suspension with vigorous stirring. The temperature of the reaction mixture was increased to 45°, 153 g. of allyl chloride was added, and the temperature was maintained at 45° for an additional nine hours. The cooled mixture was filtered to remove sodium chloride and unreacted pentaerythritol and concentrated. The residual mixture of allyl pentaerythritol ethers was fractionated at 1 mm. pressure.

Diallyl pentaerythritol ether, b.p. 120° (1 mm.), n^{20}D 1.4729, d^{20}_{20} 1.046, was obtained in a yield of 35% based on the allyl chloride. *Anal.* Calcd. for $C_{11}H_{20}O_4$: C, 61.08; H, 9.32. Found: C, 61.25; H, 9.09.

---

(1) Publication approved by the Bureau of Ordnance, Navy Department.

(2) P. L. Nichols, Jr., and E. Yanovsky, THIS JOURNAL, **67**, 46 (1945).