Regeneration of the ketone as described above yielded 3.8 g. (10.5%) of colorless 3-ethyl-5-isopropyl-2-cyclohexenone, having a sweet odor faintly reminiscent of both camphor and dill, b. p. 123° (11 mm.); $n^{20}D$ 1.4862; sp. gr. $^{20}_{20}$ 0.927; *MR* calcd. (no exaltation), 50.5; *MR* found, 50.9. Ultraviolet absorption showed a maximum at 235 mμ (log ε 4.10, 0.006 g. per liter of 95% ethanol solution).

Anal. Calcd. for $C_{11}H_{18}O$: C, 79.47; H, 10.91. Found: C, 79.33; H, 11.18.

2,3-Dimethyl-5-isopropyl-2-cyclohexenone (X).—To a Grignard reagent prepared from 14.0 g. (0.61 gram-atom) of magnesium, 91.6 g. (0.63 mole) of methyl iodide and 200 ml. of dry ether was added with stirring over a period of thirty minutes 44.6 g. (0.29 mole) of 2-methyl-5-isopropyl-1,3-cyclohexanedione. Two hundred fifty milliliters of benzene was added, the ether distilled, and the mixture refluxed with stirring for five hours. It was then poured onto ice, acidified with hydrochloric acid, and filtered. The layers were separated, the water layer extracted with benzene, and the combined benzene solutions distilled in an eight-inch helix-packed column to give 11.5 g. of impure product, b. p. 80–111° (4 mm.). Reaction with 10 g. of semicarbazide hydrochloride yielded 6.7 g. of semicarbazone, rhombs from ethanol, m. p. 202–203°.

Anal. Calcd. for $C_{12}H_{21}ON_3$: C, 64.54; H, 9.48. Found: C, 64.83; H, 9.69.

Regeneration of the ketone as described above gave 2.1 g. (4.4%) of product, similar in odor to carvotanacetone but sweeter, b. p. 123° (12 mm.); $n^{20}D$ 1.4900; sp. gr. $^{20}_{20}$ 0.927; *MR* calcd. (no exaltation), 50.5; *MR* found, 51.8. Ultraviolet absorption showed a peak at 243.5 mμ (log ε 4.14, 0.006 g. per liter of 95% ethanol solution).

Anal. Calcd. for $C_{11}H_{18}O$: C, 79.47; H, 10.91. Found: C, 79.75; H, 11.14.

Summary

Cyclic 1,3-diketones such as 5-isopropyl-1,3-cyclohexanedione have been investigated as starting materials for the synthesis of monocyclic terpenes. It has been found that such diketones can be converted in good yields to 2-cyclohexenones by the intermediate formation of 3-chloro-2-cyclohexenones and subsequent reductive dehalogenation with zinc and potassium iodide or by reduction of their enol ethers by means of lithium aluminum hydride. *dl*-Carvotanacetone and a number of analogs of this natural terpene have been synthesized in the course of the investigation.

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[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY OF THE UNIVERSITY OF DELAWARE]

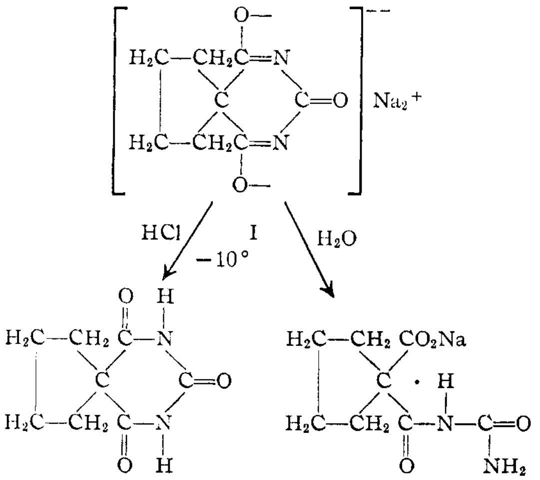
The Relative Instability of a C_5-Spirobarbituric Acid

BY GLENN S. SKINNER, GEORGE LIMPEROS AND RUSSELL H. PETTEBONE

The 1,1-dicarboxylic ester derivatives of cyclobutane and cyclohexane both yield stable spirocycloalkane-1,5'-barbituric acids.[1] The corresponding cyclopropane derivative, however, yields polymeric material.

It is significant that the esters having an even number of carbon atoms in the ring yielded barbituric acid derivatives which were stable under the vigorous conditions used in their preparation and the results suggest an alternation in the effect of the size of the ring. Accordingly, we condensed cyclopentane-1,1-dicarboxylic ester with urea under the mild conditions employed for the lactone esters.[2] A disodium salt (I) was formed with similar ease. The molecule of ethyl alcohol, however, did not remain when the sample was dried to constant weight under similar conditions. Moreover, in aqueous solution, the salt (I) decomposed rapidly into (II) with the cleavage of the barbituric acid ring. The barbituric ring remained intact while the other ring was opened when the condensation product from a lactone ester was treated similarly. By addition of the salt (I) to a freezing mixture of ice and hydrochloric acid the spirobarbituric acid (III) was obtained.

Δ^3-Cyclopentene-1,1-dicarboxylic ester gave no monomeric barbituric acid and the ester itself underwent polymerization in the alkaline medium even in an atmosphere of hydrogen. The pure ester polymerized slowly. The following physical constants of a freshly distilled sample were determined for comparison with those of the saturated ester.



III II

	$n^{25}D$	d^{25}
$(—CH_2CH_2—)_2C(CO_2C_2H_5)_2$	1.4390	1.0186
$(=CHCH_2—)_2C(CO_2C_2H_5)_2$	1.4500	1.0168

MR Calcd.	*MR* Found	$^a\eta^{25°}$	$^b\gamma^{25°}$	*P* Calcd.	*P* Found
54.93	54.70	0.03525	30.96	488.1	496.6
53.65	55.94	.04847	30.68	478.1	490.7

[a] Ostwald viscosimeter. [b] Capillary rise method.

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[1] Dox and Yoder, THIS JOURNAL, **43**, 677, 1366, 2097 (1921).

[2] Skinner, Stokes and Spiller, *ibid.*, **69**, 3083 (1947).

Experimental

1,4-Dibromo-2-butene.—This compound has been made from 1,3-butadiene with the aid of various solvents.[3,4] We prefer to pass 1,3-butadiene (100 g.) into carbon disulfide (900 g.) which is stirred and cooled in a bath of salt and ice. Bromine (280 g.) is then added, dropwise, during eight to nine hours. The carbon disulfide is removed under diminished pressure at room temperature and the product, chiefly 3,4-dibromo-1-butene, is distilled, b. p. 85–87° (10 mm.). The liquid distillate, which contains some crystals of the rearranged product is heated at 85–90° for thirty minutes and then cooled in ice-cold water. The crystalline material is filtered with suction and the filtrate is treated again in the same way. To prevent isomerization back to the liquid isomer, the crystals of 1,4-dibromo-2-butene are pressed between filter paper to remove remaining liquid and then stored in glass-stoppered bottles; yield 85–90%; m. p. 53–54°. All operations should be done in the hood and the operator should wear gloves.

Cyclopentane-1,1-dicarboxylic Ester.—The mixture prepared from 85 g. of ethyl malonate, 25.3 g. of sodium and 800 cc. of absolute alcohol was added during two hours to 114.5 g. of tetramethylene bromide which was stirred and maintained at 65–70°. After heating six hours longer at this temperature the product was finally fractionated; b. p. 97–98° (3 mm.); yield 73.5 g. (65%). It was identified as the desired compound[5] by conversion to cyclopentane-1,1-dicarboxylic acid, m. p. 184–185°, and cyclopentanecarboxylic acid, b. p. 209–210 (747 mm.).

Δ^3-Cyclopentene-1,1-dicarboxylic Ester.—This ester was obtained in the same way from 14.3 g. of sodium, 300 cc. of absolute alcohol, 48 g. of ethyl malonate and 64.2 g. of 1,4-dibromo-2-butene. The yield was 48.4 g. (76%), b. p. 80–81° (0.5 mm.).

Anal. Calcd. for $C_{11}H_{16}O_4$: C, 62.24; H, 7.59. Found: C, 61.71; H, 7.15.

The viscosity of redistilled material was measured during a period of seven days and found to be constant. After three months, evidence of polymerization was provided by the formation of a very viscous liquid containing a transparent solid.

Condensation of the 1,1-Dicarboxylic Esters with Urea.—To a solution of sodium ethoxide prepared from 10.35 g. of sodium and 200 cc. of absolute alcohol were added 18.02 g. of urea and 32.14 g. of cyclopentane-1,1-dicarboxylic ester with rapid stirring at 18°. The mixture was stirred at 45° until the urea dissolved and then heated four hours longer at this temperature. After fifteen hours the mother liquor was withdrawn through a filter stick. While still in the flask protected from moisture the solid was stirred and washed six times with 50-cc. portions of absolute alcohol. It was then filtered and washed on a Buchner funnel with the aid of a rubber dam. The product (I) was dried in a vacuum desiccator; yield 19.6 g. (57.6%).

Anal. Calcd. for $C_8H_8O_3N_2Na_2$: Na, 20.3; N, 12.39. Found: Na, 19.6; N, 12.45.

When the disodium salt was dissolved in water and then acidified, the product which precipitated varied in the different experiments and the expected spirobarbituric acid was not obtained in this manner. It was isolated by stirring the dry salt into a mixture of ice and hydrochloric acid. From 6.92 g. of the disodium salt, 7.0 cc. of concd. hydrochloric acid and 30 g. of ice there was obtained 4.11 g. (74%) of spirocyclopentane-1,5′-barbituric acid, m. p. 268–269°. After crystallization from 400 cc. of boiling water it melted sharply at 269–269.5°.

Anal. Calcd. for $C_8H_{10}O_3N_2$: N, 15.38. Found: N, 15.51.

Since the behavior of the disodium salt of spirocyclopentane-1,5′-barbituric acid indicated rapid hydrolysis in alkaline solution, 1.82 g. of the acid was added to a cold stirred solution prepared from 0.5 g. of sodium hydroxide and 10 cc. of water. The solution was allowed to stand at 33° protected from evaporation. The acid, which was precipitated from an ice-cold aliquot portion after one hour, sintered at 98–99° and decomposed at 119–121°; after two hours it sintered at 128° and decomposed at 130°. The decomposition point did not change after four days. Another solution of the same concentration which stood at 26° for four days gave an acid which sintered at 120–124° and decomposed at 124–128°; after eight days at this temperature it sintered at 128° and decomposed at 130°. This acid, corresponding to the salt (II), could be recrystallized from a concentrated solution in hot water. When dry, it decomposed sharply at 130°.

Anal. Calcd. for $C_8H_{12}O_4N_2$: N, 14.00; neut. equiv., 200. Found: N, 13.95; neut. equiv., 208.

When Δ^3-cyclopentene-1,1-dicarboxylic ester was added to an alcoholic solution of urea and sodium ethoxide a plastic material, which contained no nitrogen, immediately formed. In a hydrogen atmosphere less of this material was obtained and after two hours the liquid mixture had gelled. No pure product was isolated but condensation had taken place since it contained 12.01% of nitrogen.

Summary

1. Physical properties of the diethyl esters of cyclopentane-1,1-dicarboxylic and Δ^3-cyclopentene-1,1-dicarboxylic acids are reported.

2. Diethyl cyclopentane-1,1-dicarboxylate condenses with urea under mild conditions to form the relatively unstable disodium salt of spirocyclopentane-1,5′-barbituric acid.

NEWARK, DELAWARE RECEIVED SEPTEMBER 15, 1949

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[3] Griner, *Bull. soc. chim.*, [3] **9**, 218 (1893).

[4] Farmer, *et al.*, *J. Chem. Soc.*, 729 (1928).

[5] Haworth and Perkins, *ibid.*, **65**, 86-105 (1894).