light that is characteristic of the phenazines of *o*-quinones.[13] The same results were obtained with α-tocored.[14]

Isomerization of the Orange Band Material and of Tocored.—A yellow solution, with a yellowish-brown oil floating on top, was produced when a mixture of 35 mg. of the red oil from the orange band and 20 ml. of 6 *N* hydrochloric acid was refluxed for 2 hr. The concentrated and dried ethereal extract of this mixture was chromatographed on the zinc carbonate column; three colored bands appeared, a purple (absorbing at 305 mμ) an orange (absorbing at 260, 270 and 460 mμ) and a yellow band (absorption maximum at 289 and a minimum at 255 mμ). The oil from the yellow band was only slightly soluble in methanol, and it gave an orange coloration in glacial acetic acid. Identical results were obtained with α-tocored.

Reductive Acetylation of the Orange Band Material and of Tocored.—The red color faded to a pale yellow when a mixture composed of 50 mg. of the red oil from the orange band, 10 ml. of pyridine, 10 ml. of acetic anhydride and 1.5 g. of powdered zinc was stirred for 1 hr. Cold water was then added and the resulting mixture was extracted with successive portions of diethyl ether. A pale-yellow, sweet-smelling oil (absorption maximum at 240 mμ) was recovered from the combined ethereal extracts. This oil was only slightly soluble in methanol, but was very soluble in ether. White needles, m.p. 70°, appeared when a solution of the oil in diethyl ether–methanol was chilled to −5°.

Anal. Calcd. for $C_{32}H_{52}O_5$: C, 74.38; H, 10.14. Found: C, 74.20; H, 10.49.

The oily acetate from a comparable treatment of tocored showed an absorption maximum at 240 mμ, and the white needles obtained in the manner indicated above melted at 69–70° and did not depress the melting point of the above diacetate.

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(13) S. C. Hooker, THIS JOURNAL, **58**, 1163, 1168, 1181, 1198 (1936).

(14) W. John and W. Emte,[10] report absorption maxima for this phenazine at 270 and 365 mμ.

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Epimeric 5-Hydroxy-2-ketocyclohexaneacetic Acids

BY E. M. FRY

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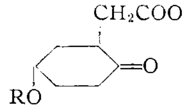
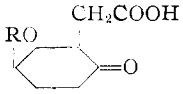
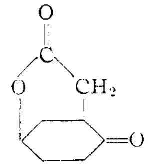
The stabilities of isomeric substituted cyclohexane derivatives are now related to the idea of a chair form for the ring with substituents occupying either equatorial or polar positions. In systems in which the interaction of groups is mainly of a steric nature the equatorially substituted compounds are considered to be the more stable. Thus in a disubstituted compound the more stable forms are *trans*-1,2,*trans*-1,4 and *cis*-1,3 since the substituents can assume an equatorial position, whereas the *cis*-1,2,-*cis*-1,4 and *trans*-1,3 forms are less stable because one of the substituents is polar oriented.[1] In support of this concept evidence is here presented that in an equilibrating solution of the epimeric 5-hydroxy-2-ketocyclohexaneacetic acids Ia and IIa, the *cis* form is the more favored.

The preparations of the epimeric benzyl ethers Ib and IIb have been described.[2] When the liquid isomer IIb was dissolved in 9 *N* hydrochloric acid an oil began to separate within a few seconds. This oil readily crystallized to yield the epimeric benzyl ether Ib.







Ia, R = H, m.p. 120° IIa, R = H, m.p. 150° III
b, R = $C_6H_5CH_2$, m.p. 110° b, R = $C_6H_5CH_2$, liquid

This separation of oil indicates that in the liquid as well as in the crystalline state Ib is much less soluble in the acid than its precursor IIb. The solid isomer was dissolved in the large volume of hydrochloric acid necessitated by its low solubility and then removed with chloroform in which it is very soluble. After several chloroform extractions 37% of the solid isomer was recovered along with an oil which was identified as the liquid isomer by converting it to the solid in the usual manner. This material accounted for an additional 36% of the starting material for a total recovery of 73%.

It is evident that this combination of high solubility in chloroform and low solubility in 9 *N* hydrochloric acid favored removal of the solid isomer from the acid solution, and that 37% is probably a higher value than is actually present, since rapid equilibrating forces during and between extractions would favor formation of the isomer more easily removed by chloroform. Hence it may be concluded that the liquid benzyl ether IIb is the more stable of the two.

Proof of structure depended on finding which of the debenzylated products Ia and IIa yields the lactone III. The benzyl ethers readily underwent hydrogenolysis to give crystalline alcohols. That from the solid (less stable) benzyl ether was obtained with more difficulty owing to the ease with which it isomerized on the palladium–carbon catalyst during hydrogenolysis to give a mixture which was difficult to separate into its component epimeric alcohols. This circumstance together with the recovery in an impure state after acid equilibration of the alcohols of slightly over 50% of epimer IIa indicates that the order of stability for the alcohols is the same as that of the benzyl ethers, but this point is not yet firmly established.

The lactone was obtained in poor yield (13–21%) from both epimers after prolonged heating at 130°. As alkaline hydrolysis of the ketolactone III might lead to epimerization (and indeed gave an impure product), the position adjacent to the ketone function was made less sensitive to anionic attack by converting the lactone to its semicarbazone before hydrolysis. Hydrolysis yielded the semicarbazone of the compound IIa derived from the liquid benzyl ether IIb, thus establishing the *cis* orientation of its groups. The semicarbazone of the isomeric compound Ia was unaltered by the alkaline conditions used to hydrolyze the lactone, hence there is no question of epimerization occurring in this sequence. As the melting points of the semicarbazones were close together and that of a mixture was not depressed, identifications were based on the

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(1) For an excellent review with the pertinent references see D. H. R. Barton, The Tilden Lecture, *J. Chem. Soc.*, 1027 (1953). Papers which were in press at the time of that lecture are: H. L. Goering and C. Serres, THIS JOURNAL, **74**, 5908 (1952); D. S. Noyce and D. B. Denny, *ibid.*, **74**, 5912 (1952); and J. A. Mills, *J. Chem. Soc.*, 260 (1953). Also see S. Siegel, THIS JOURNAL, **75**, 1317 (1953); G. A. Haggis and L. N. Owen, *J. Chem. Soc.*, 408 (1953); and L. H. Darling, A. K. Macbeth and J. A. Mills, *ibid.*, 1364 (1953).

(2) E. M. Fry, *J. Org. Chem.*, **17**, 1484 (1952).

characteristic infrared diagrams. The structures previously assigned to these compounds are confirmed by this work.

Experimental

Hydrogenolysis of Epimeric Benzyl Ethers. A. *trans*-5-Hydroxy-2-ketocyclohexaneacetic Acid (Ia).—Three and five-tenths grams of *trans*-5-benzyloxy-2-ketocyclohexaneacetic acid, m.p. 109–111°, in solution in 35 ml. of 95% ethanol with 1.8 g. of 5% palladium–charcoal catalyst absorbed the theoretical amount of hydrogen on shaking for an hour at room temperature. The catalyst was filtered and the alcohol removed under reduced pressure at room temperature. A total of 2.0 g. (87%) of product, m.p. 112–115°, was recovered from a cold suspension in ethyl acetate. It was purified by dissolving in a little warm alcohol and adding ethyl acetate. The analytical sample melted at 119–121°.

Anal. Calcd. for $C_8H_{12}O_4$: C, 55.80; H, 7.03. Found: C, 55.82; H, 7.26.

In another similar run in 95% ethanol the absorption of hydrogen was 150% and the yield only 62%. In acetone there was no tendency to over reduce, but the product was usually impure and difficult to separate into its components.

The semicarbazone was purified from water, m.p. 188–189° (gas).

Anal. Calcd. for $C_9H_{15}N_3O_4$: N, 18.33. Found: N, 18.42.

An alkaline solution of the semicarbazone was made by adding 0.2 ml. of 2.16 *N* sodium hydroxide solution to a suspension of 0.050 g. in 0.2 ml. of water. After 30 minutes 0.14 ml. of 3.02 *N* hydrochloric acid precipitated 0.027 g. of the semicarbazone and an additional 0.010 g. was obtained from the mother liquor. Infrared diagrams established the fact that this treatment did not cause isomerization to the epimeric semicarbazone.

B. ***cis*-5-Hydroxy-2-ketocyclohexaneacetic Acid (IIa).**—Five grams of *cis*-5-benzyloxy-2-ketocyclohexaneacetic acid (liquid isomer of *ca.* 70% purity[2]) in solution in 50 ml. of acetone with 3 g. of 5% palladium–charcoal catalyst absorbed 470 ml. of hydrogen on shaking for 90 minutes at room temperature. The catalyst was filtered and washed with acetone. The solvent was removed at room temperature under reduced pressure, and the crude product washed with cold ethyl acetate. It weighed 1.88 g. (57%) and melted at 140–143°. After further purification by adding ethyl acetate to a hot alcohol solution it melted at 150–152°.

Anal. Calcd. for $C_8H_{12}O_4$: C, 55.80; H, 7.03. Found: C, 55.54; H, 7.22.

The semicarbazone was prepared in and purified from water. After sintering at *ca.* 135°, it resolidified and melted with decomposition at 185°. A mixture with the semicarbazone of *trans*-5-hydroxy-2-ketocyclohexaneacetic acid showed no melting point depression.

Anal. Calcd. for $C_9H_{15}N_3O_4 \cdot H_2O$: C, 43.72; H, 6.93; N, 17.00. Found: C, 43.41; H, 6.68; N, 16.65.

5-Hydroxy-2-ketocyclohexaneacetic Acid Lactone (III).—Five-tenths gram of 5-hydroxy-2-ketocyclohexaneacetic acid, m.p. 149–152°, was melted and the temperature lowered to 130° where partial solidification occurred. The compound was maintained at this temperature for 3 hours. At the end of the first hour the magma had completely liquefied. The oil was then extracted with a benzene–chloroform mixture and the crude lactone–acid mixture dissolved in water and excess calcium carbonate added to react with the acid. Water was removed under reduced pressure with warming and the residue extracted with ethyl acetate. After removal of ethyl acetate the crude product was recovered from a suspension in ether, wt. 0.058 g. (13%), m.p. 95–116°. After purification by adding ether to a benzene solution it melted at 115–118°. The same compound, identified by a mixture melting point determination, was isolated in 21% yield from a similar treatment of the epimeric acid.

Anal. Calcd. for $C_8H_{10}O_3$ (154.2): C, 62.32; H, 6.54. Found: C, 62.56; H, 6.72.

Rast molecular weight determinations on the lactone and its precursor acid were high but the gentler Signer method gave a value of 152.5 for the lactone. The lactone semicarbazone was purified from water and melted at 205–206° (gas).

Anal. Calcd. for $C_9H_{13}N_3O_3$: N, 19.90. Found: N, 19.66.

Lactone Hydrolysis.—To a suspension of 0.052 g. of the lactone semicarbazone in 0.2 ml. of water was added 0.15 ml. of 2.16 *N* sodium hydroxide solution. The solid dissolved in 5 minutes. Acidification with 0.12 ml. of 3.02 *N* hydrochloric acid gave 0.050 g. of *cis*-5-hydroxy-2-ketocyclohexaneacetic acid semicarbazone. This material gave an infrared diagram identical with that from the semicarbazone of the keto acid melting at 150–152°.

Epimerization Experiments. A.—One gram of 5-benzyloxy-2-ketocyclohexaneacetic acid (Ib), m.p. 109–111°, was suspended in 120 ml. of 9.3 *N* hydrochloric acid and the mixture shaken intermittently. After 2 hours, 50 mg. of undissolved solid was removed by filtration. The solution was extracted several times with chloroform and the chloroform removed from the extract at room temperature under reduced pressure. The crude crystalline residue weighed 0.82 g. It was purified by means of an ether suspension chilled by Dry Ice–acetone. The recovered material melted at 104–108° and weighed 0.374 g. The oil, 0.424 g., recovered from the ether could not be induced to crystallize further. Rapid crystallization occurred on triturating with 0.9 ml. of 9.3 *N* hydrochloric acid. The crystals melted at 103–109° and weighed 0.36 g.

B.—A solution of 0.20 g. of *trans*-5-hydroxy-2-ketocyclohexaneacetic acid (Ia), m.p. 118–119°, in 0.4 ml. of 6 *N* hydrochloric stood for one hour at room temperature. The hydrochloric acid was removed with an oil pump at room temperature. Ethyl acetate was added to the residue and crystallized material obtained, wt. 0.11 g., m.p. 139–145°. After further purification it melted at 150–153° and the melting point was not depressed on admixture with a sample of the *cis* isomer.

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Displacement Reactions in the Benzotriazole Series

BY NORMAN G. GAYLORD

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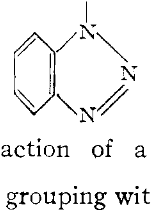
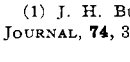
It has been shown that the treatment of benzotriazole with formaldehyde yields 1-hydroxymethylbenzotriazole (I).[1] Catalytic hydrogenation in the presence of Raney nickel or 5% palladium-on-charcoal failed to reduce I to 1-methylbenzotriazole (II). However, conversion of I by means of thionyl chloride to the corresponding halide, followed by reduction with lithium aluminum hydride in refluxing tetrahydrofuran gave II.[1]



I, R = OH
II, R = H

The reaction of a compound containing an  $-\overset{|}{N}-\underset{|}{\overset{|}{C}}-O-$ grouping with lithium aluminum hydride

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[1] J. H. Burckhalter, V. C. Stephens and L. A. R. Hall, THIS JOURNAL, **74**, 3868 (1952).