TABLE I

SUMMARY OF HYDROGENATION EXPERIMENTS

| Starting compound | Catalyst and solvent | Product | Yield, % | M.p., °C. | [α]D | Empirical formula | Carbon, % Calcd. | Carbon, % Found | Hydrogen, % Calcd. | Hydrogen, % Found | Recrystn. solvent |
|---|---|---|---|---|---|---|---|---|---|---|---|
| II | Pd/CaCO₃; | III | 96.5 | 207.4–208.8[a] | 0.0° | $C_{21}H_{34}O_2$ | 79.19 | 79.09 | 10.76 | 11.06 | Methanol |
| | pyridine | III acetate | | 154.8–155.6 | − 9.4 | $C_{23}H_{36}O_3$ | 76.62 | 76.83 | 10.07 | 10.25 | |
| IV | PtO₂; HAc | V | 97.5 | 219.0–220.4[b] | −30.5 | $C_{21}H_{36}O_2 \cdot H_2O$ | 74.51 | 74.76 | 11.32 | 11.26 | MeOH–H₂O |
| | | Va | | 166.2–167.4 | −14.2 | $C_{23}H_{38}O_3$ | 76.19 | 76.22 | 10.56 | 10.61 | |
| IV | Pd/C; HAc | Va | 65.0 | 165.8–166.8 | | | | | | | MeOH–H₂O |
| V | Pd/C; HAc | Va | 80.0 | 167.6–168.0 | −15.7 | | | | | | MeOH–H₂O |
| VI | Pd/C; HAc | Va | 68.5 | 166.4–167.4 | | | | | | | MeOH–H₂O |
| II | Pd/C; HAc | Va | 97.0 | 167.2–168.2 | −14.2 | | | | | | MeOH–H₂O |
| VIII | Pd/C; HAc | IXa | 70.0 | 115.0–115.4[c] | + 7.4 | $C_{23}H_{38}O_2$ | 79.71 | 79.78 | 11.03 | 11.06 | Methanol |
| | | IX | | 138.0–138.4[d] | +21.9 | $C_{21}H_{36}O$ | 82.83 | 82.61 | 11.92 | 11.98 | Methanol |

[a] Lit. m.p. 207° [ref. 4; A. Serini and W. Logemann, *Ber.*, **71**, 1362 (1938)]. [b] Lit. m.p. 204–205° [L. Ruzicka, M. W. Goldberg and H. R. Rosenberg, *Helv. Chim. Acta*, **18**, 1487 (1935)], m.p. 221–222°; [T. Reichstein and K. Gätzi, *ibid.*, **21**, 1185 (1938)]. [c] Lit. m.p. 115–116° [L. Ruzicka, M. Goldberg and E. Hardegger, *ibid.*, **22**, 1294 (1939)]. [d] Lit. m.p. 137–138° [note *c*].

3.92 g. of II (71.8%), m.p. 262.2–263.6°, [α]D −42.6°; lit. m.p. 255–257°,[3] 257°.[4]

*Anal.* Calcd. for $C_{21}H_{32}O_2$: C, 79.69; H, 10.19. Found: C, 80.00; H, 10.27.

The 3-acetate, prepared by the action of acetic anhydride and pyridine, had m.p. 202–204°, [α]D −40.4°.

*Anal.* Calcd. for $C_{23}H_{34}O_3$: C, 77.07; H, 9.55. Found: C, 77.43; H, 9.49.

**Hydrogenation Reactions.**—These were all run at room temperature and atmospheric pressure using 15–25% by weight of catalyst. The hydrogenations were stopped when uptake had essentially ceased, the catalyst removed by filtration and the filtrate taken to a residue under vacuum. This residue was then either saponified to remove traces of esters that formed during the hydrogenation from the action of the acetic acid solvent, or was completely acetylated by means of acetic anhydride in pyridine. These products were then crystallized from appropriate solvents. The results are summarized in Table I.

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[3] L. Ruzicka and K. Hofmann, *Helv. Chim. Acta*, **20**, 1280 (1937).

[4] J. Kathol, W. Logemann and A. Serini, *Naturwissenschaften*, **25**, 682 (1937).

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## Characterization of α-Keto Acids as Quinoxalinols[1]

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The reaction of pyruvic acid and its homologs with *o*-phenylenediamine is known to give 3-alkyl-2-hydroxy quinoxalines (3-alkyl-2-quinoxalinols), but these have not been used to characterize the α-keto acids. Since a number of α-keto acids, corresponding to the natural amino acids, were desired for work in progress in this Laboratory, it was decided to prepare the quinoxalinols for analytical derivatives. These compounds have an advantage over 2,4-dinitrophenylhydrazones, etc., in that most other carbonyl compounds do not readily form precipitates with the diamine, and the products are stable and easily purified substances.

The α-keto acids were obtained by a modification of the method of Wieland,[2] involving reaction of a Grignard reagent with diethyl oxalate. This author gives experimental details for the synthesis of only two of the keto acids, but his method was found to be easily extendable to others. Reaction of the aqueous α-keto acid with a solution of *o*-phenylenediamine in dilute acetic acid caused rapid crystallization of the desired quinoxalinol, which was obtained in about 80% yield.

Of the 3-alkyl-2-hydroxyquinoxalines with simple and unsubstituted alkyl groups, only three are mentioned in the literature. These are: 3-methyl,[3,4] 3-ethyl[4] and 3-*t*-butyl.[5] Five additional representatives of the class were prepared in the present work, and these are listed in Table I along with melting points and analyses. The previously known compounds and the unsubstituted 2-quinoxalinol[6] are also listed for comparison.

TABLE I

3-ALKYL-2-QUINOXALINOLS

| 3-Alkyl[a] group | M.p., °C. | Analyses, % Carbon Calcd. | Analyses, % Carbon Found | Analyses, % Hydrogen Calcd. | Analyses, % Hydrogen Found |
|---|---|---|---|---|---|
| None | 271[6] | ... | ... | .. | .. |
| Methyl | 245[3] 250[4] | ... | ... | .. | .. |
| Ethyl | 198[4] | ... | ... | .. | .. |
| *n*-Propyl | 182–183 | 70.21 | 70.57 | 6.38 | 6.51 |
| Isopropyl | 228.5 | 70.21 | 70.35 | 6.38 | 6.42 |
| *n*-Butyl | 153.5–154 | 71.29 | 71.43 | 6.93 | 6.55 |
| Isobutyl | 186–187 | 71.29 | 71.41 | 6.93 | 6.85 |
| *s*-Butyl | 180–181 | 71.29 | 71.28 | 6.93 | 6.85 |
| *t*-Butyl | Dec. above 300[5] | ... | ... | .. | .. |

[a] With the exception of the *t*-butyl compound, all were prepared from the corresponding α-keto acid.

### Experimental

The reaction with α-ketovaleric acid is used as a representative example. A solution of 1.143 g. (9.85 mmoles) of the keto acid in 25 ml. of water was added slowly, with stirring, to a solution of 4 g. (37.0 mmoles, an excess) of *o*-phenylenediamine in 50 ml. of 10% acetic acid. The solution darkened temporarily, and then formed a crystalline, voluminous precipitate of 3-*n*-propyl-2-quinoxalinol. After standing five hours, the suspension was filtered and the product washed with water and dried in air. There was a slight loss on washing but the filtrates, when concentrated, gave a little more product. The yield of dried, white quinoxalinol, obtained in two crops, was 1.523 g. (8.1 mmoles) or 82%.

Other quinoxalinols were prepared similarly and were recrystallized from benzene or aqueous acetone for analysis.

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[2] T. Wieland, *Ber.*, **81**, 314 (1948); *C. A.*, **43**, 4227 (1949).

[3] O. Hinsberg, *Ann.*, **292**, 249 (1896).

[4] Y. L'Italien and C. K. Banks, THIS JOURNAL, **73**, 3246 (1951).

[5] F. Krohnke, *Ber.*, **80**, 298 (1947); *C. A.*, **42**, 3747 (1948).

[6] A. H. Gowenlock, G. T. Newbold and F. S. Spring, *J. Chem. Soc.*, 622 (1945).