Anal. Calcd. for $C_7H_5O_2Br$: Br, 39.77. Found: Br, 39.93.

The anils studied in this investigation are described in Table II. Of these, twenty-eight compounds have been prepared for the first time, as far as we have been able to ascertain. Most of the compounds are readily formed by heating alcoholic solutions of the aldehyde and base; others require prolonged heating in the solvent. A few were formed only on direct heating, without a solvent. The phototropic and thermotropic properties of each compound are indicated in the table.

The anils formed from *m*-nitraniline, *p*-nitraniline, *p*-bromoaniline, 2,4-dichloroaniline, and *p*-phenylenediamine with 5-bromosalicylaldehyde were obtained only on direct fusion without a solvent. The *p*-aminoazobenzene derivative of 5-bromosalicylaldehyde, first obtained from alcohol in the yellow-brown form, on recrystallization from nitrobenzene changes to the red modification. When the red modification is dissolved in acetone and precipitated by addition of alcohol, the yellow-brown modification is again obtained.

Summary

1. A series of twenty-eight new anils, derivatives of 5-bromosalicylaldehyde, has been prepared.
2. Three new instances of phototropy are reported.
3. Twenty-two of the anils are thermotropic.
4. A number of the compounds appear to exist in two forms.

PULLMAN, WASHINGTON

RECEIVED AUGUST 8, 1932
PUBLISHED FEBRUARY 9, 1933

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

Asymmetric Syntheses. II. The Action of Optically Active Nitrates on Cyclic Ketones

BY R. L. SHRINER AND E. A. PARKER

The condensation of 4-methylcyclohexanone with *d*- or *l*-2-octyl nitrite in the presence of sodium ethylate gave an optically active sodium salt of the oxime.[1] This reaction constituted a new type of asymmetric synthesis since the optically active octyl group was split off during a reaction which created an asymmetric carbon atom in the molecule. A second example of this type of asymmetric synthesis has been found in the condensation of 4-methylcyclohexanone and optically active alkyl nitrates.

Previous investigators have shown that alkyl nitrates in the presence of potassium ethylate readily condense with fluorene,[2] phenylacetic ester,[3] α-tetralone[4] and cyclohexanone.[5] In each case the product was the potassium salt of a nitro compound. In the present investigation the potassium salt of a nitro compound was likewise produced in accordance with the reaction

---

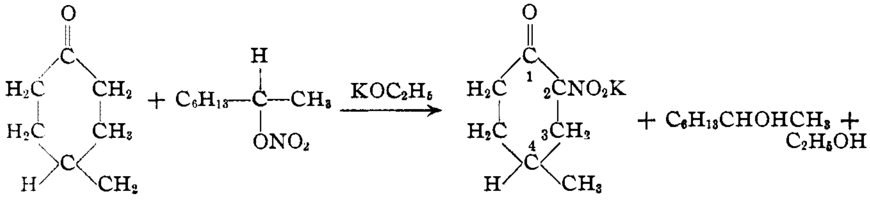
[1] Pezold and Shriner, THIS JOURNAL, **54**, 4707 (1932).

[2] Wislicenus and Waldmüller, *Ber.*, **41**, 3336 (1908).

[3] Wislicenus and Grützner, *ibid.*, **42**, 1930 (1909).

[4] Straus and Ekhard, *Ann.*, **444**, 164 (1925).

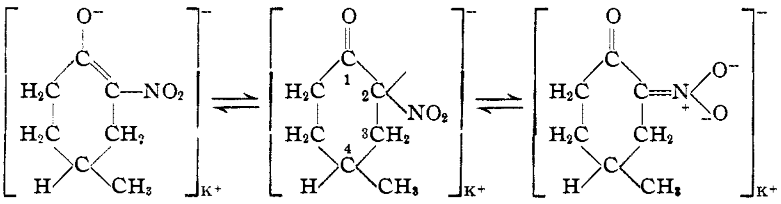
[5] Wieland, Garbsch and Chavan, *ibid.*, **461**, 295 (1928).



I II III IV

When an alcohol–ether solution of *d*-2-octyl nitrate and 4-methylcyclohexanone was treated with potassium ethylate, the *dextro* potassium salt of 2-nitro-4-methylcyclohexanone (III) precipitated. Similarly the *l*-2-octyl nitrate yielded the *levo* potassium salt. That the activity was due to these salts (III) was shown in the first place by the fact that the solid active salts could be isolated and analyzed. Second, it was shown by a control experiment that octanol-2 and potassium-2-octylate (the only other possible optically active products) remained in solution under the experimental conditions used.

This asymmetric synthesis raises a question concerning the location of the optically active center of the molecule (III). The actual cause of the optical activity of these salts may be the fact that carbon atom 4 (Formula III) carrying the methyl group is now asymmetric, in which case this reaction of 4-methylcyclohexanone with active nitrates would be strictly analogous to the previously described reaction with active nitrites.[1] Or, these compounds may constitute a third example of optically active salts of secondary nitro compounds similar to the salts of *d*- and *l*-2-nitrobutane[6] and *d*- and *l*-2-nitro-octane.[7] The chief evidence in support of this last explanation is the fact that both the *d* and *l* salts racemized completely in about one hour. It is difficult to explain this rapid racemization if the activity were due to carbon atom 4. If, however, the active salt possesses the structure V, a tautomeric shift to either form VI or VII would readily lead to racemization. This tautomeric shift should not destroy the optical activity if it is due to carbon atom 4, but should destroy any activity due to carbon atom 2.



VI V VII

By carrying out the same reaction on cyclohexanone and an active nitrate it would be possible to decide definitely between the two possibilities.

---

(6) Kuhn and Albrecht, *Ber.*, **60**, 1297 (1927).

(7) Shriner and Young, THIS JOURNAL, **52**, 3332 (1930).

This condensation was carried out but the product was very difficult to isolate. It was produced in poor yields, proved to be very hygroscopic and correct analyses for nitrogen or potassium could not be obtained. It was, however, optically active and racemized in about one hour. A further study of its preparation and isolation in the pure state is being made.

Experimental

4-Methylcyclohexanone.—This compound was prepared by the oxidation of 4-methylcyclohexanol according to the method previously described,[1] b. p. 168–170°.

***d*- and *l*-Octanol-2.**—Octanol-2 was resolved by fractional crystallization of the brucine salts of the acid phthalic ester according to the procedure in "Organic Syntheses."[8] The *d*-octanol-2 had a rotation of $[\alpha]^{25}_{D}$ +10.15 and the *l*-octanol-2 a rotation of $[\alpha]^{25}_{D}$ −10.30.

***d*-2-Octyl Nitrate.**—A modification of the method of Chapman and Smith[9] was developed for the preparation of this ester in order to avoid the production of octanone-2 noted by Bouveault and Wahl.[10] A mixture of 19.5 cc. of concentrated nitric acid, 58.5 cc. of concentrated sulfuric acid and 2 g. of urea was placed in a 400-cc. beaker and cooled to 0° with mechanical stirring. Seventeen and one-half grams of *d*-octanol-2 ($[\alpha]^{25}_{D}$ +10.15) was added from a separatory funnel through a fine capillary tube reaching to the bottom of the beaker. The temperature was maintained at 0 to 10° with vigorous stirring in an ice–salt bath. The addition of the alcohol took thirty minutes and the mixture was stirred for fifteen minutes longer. The reaction mixture was poured on cracked ice and the colorless oil was separated immediately and washed three times with ice water. The product was dried over anhydrous magnesium sulfate and vacuum distilled at 95–97° at 20 mm. The yield of 15.3 g. was 64.9% of the theoretical. Its rotation was $[\alpha]^{25}_{D}$ +14.59; n^{20}_{D} 1.4301; d^{20}_{20} 0.954; M_D (calcd.), 47.69; M_D (found), 47.39.

Anal. Calcd. for $C_8H_{17}NO_3$: N, 8.00. Found: N, 7.97.

Preparation of *l*-2-Octyl Nitrate.—This isomer was obtained by the same procedure as above. Thirty cubic centimeters of concentrated nitric acid, 90 cc. of concentrated sulfuric acid, 3 g. of urea and 27 g. of *l*-2-octanol (α_D −10.30°) gave 24.2 g. of *l*-2-octyl nitrate which was 66.5% of the theoretical; b. p. 93–94° at 17 mm.; n^{20}_{D} 1.4302; d^{20}_{20} 0.956; M_D (calcd.), 47.69; M_D (found), 47.30; α^{25}_{D} −14.64.

Anal. Calcd. for $C_8H_{17}NO_3$: N, 8.00. Found: N, 8.11.

Preparation of *dl*-2-Octyl Nitrate.—The racemic 2-octyl nitrate was obtained in the same manner from *dl*-octanol-2; b. p. 92.5–94.5° at 18 mm.; n^{20}_{D} 1.4299; d^{20}_{20} 0.951; M_D (calcd.), 47.69; M_D (found), 47.51. *Saponification equivalent.* Calcd. for $C_8H_{17}NO_3$, 175. Found: 175.5.

Reaction between 4-Methylcyclohexanone and *dl*-2-Octyl Nitrate.—One gram of potassium was dissolved in 8 cc. of absolute ethyl alcohol, 25 cc. of absolute ether was added and the solution placed in a three-necked 200-cc. flask fitted with a mercury-sealed stirrer, condenser, dropping funnel and a thermometer. The apparatus was placed in a water-bath at 40°. A mixture of 4.5 g. of 2-octyl nitrate and 6 g. of 4-methylcyclohexanone dissolved in 70 cc. of absolute ether was added slowly through the dropping funnel with the mixture refluxing. After the ether solution of the ketone and nitrate was added 50 cc. more of absolute ether was added. The mixture was stirred for two more hours, making three hours in all. The yellow precipitate was then filtered,

---

(8) "Organic Syntheses," J. Wiley and Sons, New York, 1926, Vol. VII, p. 68.

(9) Chapman and Smith, *J. Chem. Soc.*, **20**, 581 (1867).

(10) Bouveault and Wahl, *Compt. rend.*, **136**, 1563 (1903).

washed with absolute ether and dried over phosphorus pentoxide in a vacuum. The yield of 1.5 g. was 29.9% of the theoretical. The crude product contained nitrogen and 24% potassium. Two grams of the crude salt was dissolved in 150 cc. of 95% alcohol, filtered and 300 cc. of absolute ether added. The immediate precipitate was filtered and found to be orange to red in color. A fine yellow precipitate which formed overnight on standing in the ice box was filtered, dried and recrystallized in the same manner.

Anal. Calcd. for $C_8H_{10}NO_3K$: K, 20.03; N, 7.17. Found: K, 21.34; N, 7.05.

Reaction between 4-Methylcyclohexanone and *d*-2-Octyl Nitrate.—One gram of potassium was dissolved in 7 cc. of absolute alcohol, 25 cc. of absolute ether was added and the solution placed in a 200-cc. three-necked flask fitted with a condenser, mechanical stirrer, dropping funnel and a thermometer. The apparatus was placed in a water-bath at 40°. A mixture of 4.5 g. of *d*-2-octyl nitrate and 6 g. of 4-methylcyclohexanone dissolved in 40 cc. of ether was added slowly through the dropping funnel while the mixture was refluxing. After the ether solution had been added, 50 cc. more of absolute ether was added and the warm mixture stirred for one hour more, making one and a half hours from the beginning. The yellow precipitate was filtered, washed with dry ether and dried over phosphorus pentoxide in a vacuum. The yield of 1.7 g. was 33.9% of the theoretical. For purification one gram of the crude potassium salt was dissolved in 10 cc. of 95% alcohol. The solution was filtered and the salt precipitated by the addition of 300 cc. of dry ether. The immediate precipitate which came down was filtered and the solution allowed to stand in the ice box. After several hours a fine crystalline precipitate separated which was filtered and dried *in vacuo* over phosphorus pentoxide. The salt was a yellow solid which was very hygroscopic. It gave an immediate rotation of $[\alpha]_D^{25}$ +9.02° which dropped to zero in 1.1 hours.

Anal. Calcd. for $C_8H_{10}NO_3K$: K, 20.03; N, 7.17. Found: K, 20.95; N, 7.15.

Reaction between 4-Methylcyclohexanone and *l*-2-Octyl Nitrate.—This condensation was carried out in exactly the same manner as the preceding one. The product had a lower rotation of $[\alpha]_D^{25}$ −4.00°.

Anal. Calcd. for $C_8H_{10}NO_3K$: K, 20.03; N, 7.17. Found: K, 21.22; N, 7.34.

Reaction between *dl*-2-Octyl Nitrate and Potassium Ethylate.—The same procedure was used as above except that 4-methylcyclohexanone was omitted. At the end of two hours no precipitate had separated. After standing for two days a slight precipitate separated which was examined and found to be potassium nitrate. This experiment shows that potassium 2-octylate was soluble in the concentration of alcohol and ether used as the reaction solvent and hence could not contaminate the salts of the nitro compounds.

Reaction between *l*-2-Octyl Nitrate and Cyclohexanone.—This condensation was carried out by exactly the same procedure as for 4-methylcyclohexanone. After the reaction was complete the orange-brown precipitate was filtered but as soon as the ether was gone the precipitate turned to an oil. Some of the solid left in the flask was suspended in dry ether and placed in a vacuum desiccator and the ether evaporated. The solid was dried over phosphorus pentoxide in a vacuum. The material was extremely hygroscopic and turned to an oil in a few minutes if exposed to the air. A sample was weighed out and gave $[\alpha]_D^{25}$ −6.72° and the rotation decreased until at the end of one hour it was zero. All attempts to purify the compound and obtain analyses on it have failed up to the present time.

Summary

The reaction between 4-methylcyclohexanone and *d*- and *l*-2-octyl nitrate in the presence of potassium ethylate produced the *d*- and *l*-potassium salts of 2-nitro-4-methylcyclohexanone.

The optical activity of these salts appears to be due to the asymmetry of the carbon atom carrying the nitro group.

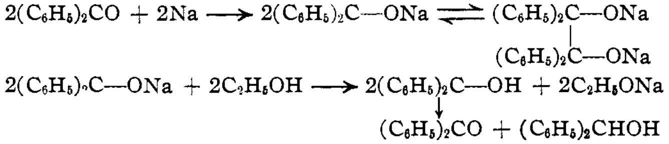
URBANA, ILLINOIS
RECEIVED AUGUST 8, 1932
PUBLISHED FEBRUARY 9, 1933

[CONTRIBUTION FROM THE CHEMISTRY LABORATORY OF THE UNIVERSITY OF MICHIGAN]

The Mechanism of Reduction by Sodium Amalgam and Alcohol. I. The Reduction of Aromatic Ketones to Hydrols

BY W. E. BACHMANN

During the reduction of benzophenone by 2% sodium amalgam and absolute alcohol two striking phenomena were observed. In the first place, the sodium amalgam is almost without action on the alcohol; when, however, benzophenone is added and the mixture is shaken, a vigorous reaction takes place with evolution of heat and in a few minutes all of the ketone is reduced to hydrol. Secondly, during the reduction the solution becomes blue, indicating the formation of the sodium ketyl $(C_6H_5)_2CONa$; the blue color rapidly disappears if shaking is discontinued. When all of the ketone has been reduced the blue color no longer reappears. When these facts are considered in conjunction with the fact that benzophenone reacts rapidly with sodium amalgam in absence of alcohol and gives the ketyl as the initial product, there can be no doubt that the reduction of the ketone is not effected by the hydrogen liberated by the action of the sodium amalgam on the alcohol; instead, the reduction occurs in virtue of the reactions



$$2(C_6H_5)_2CO + 2Na \longrightarrow 2(C_6H_5)_2C{-}ONa \rightleftharpoons \begin{array}{l}(C_6H_5)_2C{-}ONa\\ \qquad\;\, | \\ (C_6H_5)_2C{-}ONa\end{array} \qquad (1)$$

$$2(C_6H_5)_2C{-}ONa + 2C_2H_5OH \longrightarrow \begin{array}{c}2(C_6H_5)_2C{-}OH + 2C_2H_5ONa \\ \downarrow \\ (C_6H_5)_2CO + (C_6H_5)_2CHOH\end{array} \qquad \begin{array}{c}(2a)\\ \\ (2b)\end{array}$$

The sodium attaches itself to the ketone and gives the sodium ketyl which associates to sodium pinacolate with which it establishes an equilibrium; the ketyl is converted by the alcohol into a mixture of benzohydrol and benzophenone; the ketone that is regenerated in this manner then in its turn goes through the cycle of reactions until benzohydrol is the sole product. Benzopinacol may be formed by reaction of the sodium pinacolate with alcohol, but since the reaction is reversible the pinacol, like the ketyls, will ultimately be converted rapidly to ketone and hydrol.[1]

If this mechanism be correct, then it should be possible to effect complete reduction by using only as much alcohol as is required by the formulation, since no loss of reducing agent occurs through evolution of hydrogen. This was found to be the case when the reduction was carried out in a mix-

---

[1] Bachmann, THIS JOURNAL, **55**, 355 (1933).