on the amount of sodium nitromalonaldehyde used) of very pale yellow needles, m.p. 64–65°.

*Anal.* Calcd. for $C_9H_{10}N_2O_4$: C, 51.42; H, 4.80; N, 13.33. Found: C, 51.76; H, 4.80; N, 13.40.

**2-Methyl-5-nitronicotinic Acid (IV).**—A solution of 2.00 g. of the ester III in a mixture of 5 ml. of concentrated hydrochloric acid and 5 ml. of water was refluxed for one hour. The solution was diluted with 30 ml. of water and neutralized by the addition of solid sodium bicarbonate. After cooling, 1.47 g. (85%) of crude acid was obtained. Recrystallization from a mixture of 40 ml. of water and 10 ml. of alcohol gave 1.26 g. (73%) of fine, white needles which melted with decomposition at 215–215.5°, when placed in the melting point bath at 211° with the temperature rising 2° per min.

*Anal.* Calcd. for $C_7H_6N_2O_4$: C, 46.16; H, 3.32; N, 15.38. Found: C, 46.43; H, 3.62; N, 15.64.

When a small portion of IV was melted in a test-tube at atmospheric pressure and then sublimed at 60 mm., the fluffy, white sublimate was shown by melting point to be pure starting material.

**Catalytic Hydrogenation of III in Alcohol.**—A solution of 6.30 g. (0.03 mole) of III in 70 ml. of absolute alcohol was shaken with 0.05 g. of platinum oxide catalyst (American Platinum Works) for five minutes at 32–35° and a hydrogen pressure of 900 lb. After removal of the catalyst by centrifugation, the solvent was distilled on the steam-bath at 60 mm. pressure and the sirupy residue was dissolved in 100 ml. of hot benzene. Cooling gave 2.67 g. (45%) of nearly pure, fine, colorless needles of **ethyl 5-hydroxamino-2-methylnicotinate** (V). The analytical sample, prepared by recrystallization from benzene, melted at 111.5–112.5° and became slightly pink after standing for several weeks.

*Anal.* Calcd. for $C_9H_{12}N_2O_3$: C, 55.09; H, 6.17; N, 14.28. Found: C, 55.11; H, 6.28; N, 14.38.

The benzene solution from the isolation of V was evaporated to a volume of 30 ml. and 60 ml. of 60–70° petroleum ether was added. Cooling to −5° gave 2.50 g. (46%) of crude **ethyl 5-amino-2-methylnicotinate** (VI) which consisted of a yellow powder melting at 60–70°. It was used in subsequent experiments without further purification. A sharply melting, analytically pure sample was not obtained by recrystallization from various solvents. A **picrate** was obtained by mixing an aqueous solution of the amine with saturated aqueous picric acid. After recrystallization from water containing a little alcohol it formed yellow platelets which melted to a dark red liquid at 191–192°.

*Anal.* Calcd. for $C_{15}H_{15}N_5O_9$: C, 44.01; H, 3.69. Found: C, 44.48; H, 3.82.

An analytically pure sample of VI was obtained by extracting an ether suspension of the pure picrate with strong, aqueous sodium hydroxide solution until the yellow color was discharged. Evaporation of the ether and recrystallization of the residue from benzene–ligroin gave fine, white clusters, m.p. 64–65°.

*Anal.* Calcd. for $C_9H_{12}N_2O_2$: C, 59.98; H, 6.71; N, 15.55. Found: C, 59.94; H, 6.74; N, 15.87.

**Catalytic Hydrogenation of III in Acetic Acid–Acetic Anhydride.**—A solution of 0.50 g. of III in a mixture of 5 ml. of acetic acid and 1 ml. of acetic anhydride was shaken with 0.05 g. of platinum oxide catalyst for five minutes at 30–40° and a hydrogen pressure of 1500 lb. After removal of the catalyst by centrifugation, the solvent was removed on the steam-bath at 60 mm. pressure. The slightly greenish, sirupy residue of crude **ethyl 5-acetylamino-2-methylnicotinate (VIII)** could not be induced to crystallize and was not submitted for analysis. On mixing an aqueous solution of the crude product with a saturated aqueous solution of picric acid, the **picrate** was precipitated. Upon recrystallization from water it was obtained in the form of yellow clusters which sintered at 169–170° and melted to a clear, light red liquid at 170–171°.

*Anal.* Calcd. for $C_{17}H_{17}N_5O_{10}$: C, 45.24; H, 3.80; N, 15.52. Found: C, 45.28; H, 3.81; N, 15.47.

The same picrate was obtained when VI was treated successively with hot acetic anhydride, water and saturated aqueous picric acid.

**Ethyl 5-Hydroxy-2-methylnicotinate (VIII).**—A solution of 0.36 g. (0.002 mole) of VI in a mixture of 10 ml. of water and 1.0 ml. (0.018 mole) of sulfuric acid was diazotized at 0° by the addition of 0.14 g. (0.002 mole) of sodium nitrate. When the clear, yellow solution was rapidly heated to boiling, gas was evolved and the solution darkened. The reaction mixture was cooled, diluted with 10 ml. of water and neutralized to *p*H 6 by the addition of solid sodium carbonate. The desired product was isolated in low yield by ether extraction, followed by two vacuum sublimations and successive crystallizations from aqueous alcohol and benzene–ligroin, when it formed fine, colorless platelets which melted at 163–164.5°.

*Anal.* Calcd. for $C_9H_{11}NO_3$: C, 59.66; H, 6.12; N, 7.73. Found: C, 60.42; H, 6.22; N, 7.63.

**Ethyl 5-Iodo-2-methylnicotinate.**—A solution of 0.18 g. (0.001 mole) of VI in a mixture of 5 ml. of water and 0.36 ml. of sulfuric acid was diazotized at 0° by the addition of 0.10 g. of solid sodium nitrite. The yellow solution was added to a solution of 0.33 g. (0.002 mole) of potassium iodide in 5 ml. of water at 0° and the reaction was completed by heating to boiling. A light amber colored solution was obtained which was diluted with 10 ml. of water and neutralized by the addition of solid sodium bicarbonate. A tan precipitate was obtained which was recrystallized from 40 ml. of 50% alcohol, giving 0.16 g. (55%) of dark tan needles which melted at 92–92.5°. A colorless analytical sample was obtained by two vacuum sublimations, m.p. 92.5–93.5°.

*Anal.* Calcd. for $C_9H_{10}NO_2I$: C, 37.13; H, 3.46; N, 4.81. Found: C, 37.12; H, 3.52; N, 4.91.

**Hypophosphorous Acid Deamination[7] of VI.**—A solution of 0.90 g. (0.005 mole) of VI in a mixture of 30 ml. of water and 2.0 ml. (0.025 mole) of concentrated hydrochloric acid was diazotized at 0° by the addition of 0.39 g. (0.0055 mole) of sodium nitrite. After two minutes, 9.9 g. (0.075 mole) of cold 50% hypophosphorous acid was added and the mixture was allowed to stand at 0° for 16 hours. The clear solution was brought to *p*H 8 by the addition of solid sodium carbonate and the brown oil which separated was extracted with two 30-ml. portions of ether. Evaporation of the ether and distillation of the residue at 0.5 mm. gave 0.51 g. (62%) of very light yellow, oily ethyl 2-methylnicotinate (X). The picrate crystallized from water in the form of long, fine, yellow needles which melted at 145.5–146.5° (the value previously reported in the literature[3] is 146–147°). The ester was converted to 2-methylnicotinic acid hydrochloride (XI) according to the published directions.[3] After recrystallizations from ethyl acetate it melted with vigorous decomposition at 230.5–231° (the previously reported values[3] are 225 and 226°).

**Infrared absorption spectra** were determined with the Model 21 Perkin and Elmer double-beam recording infrared spectrophotometer in 0.1-mm. sodium chloride cells.

---

(7) N. Kornblum in R. Adams, "Organic Reactions," Vol. II, John Wiley and Sons, Inc., New York, N. Y., 1944, p. 262.

DEPARTMENT OF CHEMISTRY
ILLINOIS INSTITUTE OF TECHNOLOGY
CHICAGO, ILLINOIS

---

## Polarography of *p*-Chlorobenzophenone and Xanthone

BY R. A. DAY, JR., AND R. E. BIGGERS

RECEIVED AUGUST 18, 1952

In a recent publication on the polarography of aromatic ketones, several compounds were compared as to their formation of double waves in basic ethanol–water media.[1] It was pointed out that if the aromatic group attached to the carbonyl in a ketone tended to increase the stability of the dimer of a metal ketyl intermediate, double waves were likely to occur. The aromatic groups studied in this work were the 9-fluoryl, benzanthryl, phenyl and α-naphthyl.

It is known that the *p*-chlorophenyl group has less effect in stabilizing a free radical than the

---

(1) R. A. Day, Jr., S. R. Milliken and W. D. Shults, THIS JOURNAL, **74**, 2741 (1952).

phenyl group whereas the xanthyl group has a greater effect than two phenyl groups.[2] Thus one would expect that the ketone *p*-chlorobenzophenone would have a greater tendency while xanthone would have a lesser tendency to form double waves in basic media than benzophenone.

These two ketones have been studied in 25% ethanol–water media over a *p*H range of about 1 to 13. The results listed in Table I were in accord with those expected. *p*-Chlorobenzophenone gives the usual two waves in acid media, these merging at a *p*H between 4.7 and 5.6.[3] The potential of this single wave decreases to −1.52 as the *p*H is increased to 12.8. A small second wave of half-wave potential −1.61 was first observed at a *p*H of 7.5. The potential of this wave had decreased to −1.74 v. at a *p*H of 11.2. The wave was not present in 0.1 *M* NaOH (ketone concentration 2.5 × $10^{-4}$ *M*) but did appear when the base concentration was reduced to 1 × $10^{-3}$ *M*. Benzophenone at the same concentration gave only one wave in these same basic solutions.[1]

TABLE I

$E_{1/2}$ *vs.* THE SATURATED CALOMEL ELECTRODE (ALL $E_{1/2}$ VALUES ARE NEGATIVE)

| *p*H (aq.) | *p*H (alc.) | $E^1_{1/2}$ | $E^2_{1/2}$ | $E^{12}_{1/2}$[a] | $E^3_{1/2}$ | Total curr., μa. |
|---|---|---|---|---|---|---|
| | | *p*-Chlorobenzophenone[b] | | | | |
| 1.1 | 1.4 | 0.89 | .. | .. | .. | 0.75 |
| 2.7 | 3.1 | 0.93 | 1.15 | .. | .. | 1.39 |
| 4.7 | 5.1 | 1.07 | 1.26 | .. | .. | 1.57 |
| 5.6 | 6.0 | .. | .. | 1.26 | .. | 1.57 |
| 7.5 | 8.0 | .. | .. | 1.36 | 1.61 | 1.52 |
| 8.5 | 9.1 | .. | .. | 1.41 | 1.70 | 1.63 |
| 9.6 | 10.2 | .. | .. | 1.45 | 1.74 | 1.66 |
| 11.2 | 11.5 | .. | .. | 1.49 | 1.77 | 1.28 |
| 12.8 | 12.8 | ... | .. | 1.52 | .. | 1.05 |
| | | Xanthone[c] | | | | |
| 1.0 | 1.3 | 0.84 | .. | .. | .. | 0.44 |
| 2.7 | 3.2 | 0.99 | .. | .. | .. | .47 |
| 3.7 | 4.1 | 1.05 | .. | .. | .. | .42 |
| 4.7 | 5.2 | .. | .. | 1.21 | .. | 1.12 |
| 5.6 | 6.2 | .. | .. | 1.23 | .. | 0.92 |
| 6.7 | 7.2 | .. | .. | 1.26 | .. | .90 |
| 7.6 | 8.0 | .. | .. | 1.29 | .. | .83 |
| 8.6 | 9.0 | .. | .. | 1.37 | .. | .88 |
| 9.6 | 10.1 | .. | .. | 1.43 | .. | .59 |
| 12.7 | 12.7 | .. | .. | 1.45 | .. | .45 |

[a] Indicates $E_{1/2}$ of wave formed by merging waves 1 and 2. [b] Concentration of ketone 0.000250 *M*. [c] Concentration of ketone 0.000156 *M*.

In the case of xanthone, only one wave was observed over the entire *p*H range. There was a slight indication of separation of the two acid waves at a *p*H of 5.2. Considerably higher currents were observed between a *p*H of about 5 to 9 than at lower or higher *p*H values. A few runs were also made in dilute sodium hydroxide solutions. At a ketone concentration of 1.56 × $10^{-4}$ *M* and NaOH concentration of 1 × $10^{-4}$ *M* no indication of a second wave could be seen. Since benzophenone also gave only one wave under these conditions some runs were made at higher ketone concentrations. It was necessary to use 50% ethanol to keep xanthone from precipitating. At ketone concentrations of 8 × $10^{-4}$ to 1.25 × $10^{-3}$ *M* in 50% ethanol a second wave could be definitely seen with benzophenone, whereas there was only a slight indication of a second wave with xanthone.

### Experimental

The current–voltage curves were determined with a Leeds and Northrup Electro-Chemograph Type E. The instrument was normally operated at a damping of 3, the half-wave potentials being corrected by 0.056 v. for lag at this damping. The electrolysis cell, buffer solution and experimental procedure were the same as previously described.[1]

A single capillary of Corning Marine barometer tubing was used. Its characteristics were: droptime 5.0 sec., *m* = 1.858 mg./sec., determined in 25% ethanol at a *p*H of 5.5 and −1.00 v. The resistance of the cell was measured at several *p*H values and a correction for *IR* drop was made when this amounted to as much as 0.01 v.

All cell solutions were 25% by volume of 95% ethanol unless otherwise indicated. The two ketones were commercial products, purified by recrystallization. Melting points (uncor.) were: *p*-chlorobenzophenone 72–73°, xanthone 173–174°. Cell solutions of *p*-chlorobenzophenone were 2.5 × $10^{-4}$ *M*, those of xanthone 1.56 × $10^{-4}$ *M*. More concentrated solutions of the latter ketone gave precipitation when mixed with basic buffers.

Measurements of *p*H were made using a glass electrode and a Beckman model H-2 *p*H meter. A high *p*H glass electrode was used in basic media.

All experiments were run at room temperature, which was normally between 23 and 28°.

DEPARTMENT OF CHEMISTRY
EMORY UNIVERSITY
EMORY UNIVERSITY, GEORGIA

---

[2] H. Gilman, "Organic Chemistry, An Advanced Treatise," John Wiley and Sons, Inc., New York, N. Y., 1943, p. 591.

[3] All *p*H values herein are of the aqueous buffer.

---

## The Rate of Deuterium Exchange between Ethanol and Water. A Reinvestigation[1]

BY JACK HINE AND CYRUS H. THOMAS

RECEIVED OCTOBER 9, 1952

Orr has reported that the establishment of equilibrium between ethanol and heavy water is a reaction of measurable rate, having a half-time of about four hours at 25°.[2] Orr mixed samples of heavy water (about 10% D) with somewhat smaller volumes of ethanol and after an allotted time added anhydrous calcium sulfate. The calcium sulfate was removed, air-dried of the adherant ethanol and dehydrated at 150° in vacuum. The composition of the resultant mixture (containing light and heavy water and < 0.4% ethanol) was measured by determination of the density and of the refractive index (using an interferometer).

On the other hand, Jungers and Bonhoeffer found that the equilibrium between ethanol and heavy water is established too rapidly to measure.[3] These workers, however, separated their aqueous ethanol solutions by extraction with benzene.

Since the validity of the widely-held belief that all proton transfer reactions between oxygen atoms occur too rapidly to measure (by con-

---

[1] This study was carried out as part of a project sponsored by the Atomic Energy Commission.

[2] W. J. C. Orr, *Trans. Faraday Soc.*, **32**, 1033 (1936).

[3] J. C. Jungers and K. F. Bonhoeffer, *Z. physik. Chem.*, **A177**, 460 (1936).