[CONTRIBUTION FROM THE COBB CHEMICAL LABORATORY, UNIVERSITY OF VIRGINIA]

Studies in the Phenanthrene Series. XVI. Amino Alcohols and Miscellaneous Derivatives of Phenanthrene[1]

BY JACOB VAN DE KAMP, ALFRED BURGER AND ERICH MOSETTIG

An up-to-date review covering the synthetic work that has been carried out in this Laboratory as one phase of approach to the drug addiction problem[2] includes mention of a number of phenanthrene derivatives that could not, for one reason or another, be described in previous communications of this series. These scattered and disconnected experiments are therefore collectively presented in this publication.

The 3- and 9-phenanthroic acid dimethyl amides, and the β-diethylaminoethyl-3- and -9-phenanthroates, $C_{14}H_9COOCH_2CH_2N(C_2H_5)_2$, structurally resembling novocaine, were prepared by standard methods. 9-Aminomethylphenanthrene, $C_{14}H_9CH_2NH_2$, was obtained in very good yields by catalytic hydrogenation of 9-cyanophenanthrene. The primary phenanthrylethanolamines (2- and 3-isomer) were obtained in the reaction sequence: $C_{14}H_9COCH_3 \rightarrow C_{14}H_9COCH{=}NOH \rightarrow C_{14}H_9COCH_2NH_2 \rightarrow C_{14}H_9CHOHCH_2NH_2$. When 3-hydroxy-6-[2-(diethylamino)-1-hydroxyethyl]-phenanthrene was acetylated by means of acetic anhydride and pyridine, a monoacetyl derivative, acetylated on the alcoholic hydroxyl group, was obtained in yields varying from 20 to 30%. The remainder of the reaction mixture consisted chiefly of the diacetyl derivative In the series of amino alcohols we prepared, furthermore, the tetrahydroisoquinolino derivative (3-isomer) of type $C_{14}H_9CHOHCH_2NC_9H_{10}$.

In the reaction mixture resulting from the Friedel-Crafts reaction on 3-acetoxyphenanthrene, employing acetyl chloride and aluminum chloride, an isomeric 3-acetoxy-*x*-acetylphenanthrene could be isolated in small amounts (approximately 1%) in addition to the previously described 3-acetoxy-6-acetylphenanthrene.[3] It was converted via the 3-hydroxy-*x*-acetylphenanthrene to the 3-methoxy-*x*-acetylphenanthrene (m. p. 94°), which gave a mixed melting point depression with 3-methoxy-9-acetylphenanthrene (m. p. 99°), whereby position 9 for the acetyl group in the new isomer is eliminated. Furthermore, the comparison of 3-hydroxyphenanthrene-*x*-carboxylic acid (m. p. 281–284°) and 3-methoxyphenanthrene-*x*-carboxylic acid methyl ester (m. p. 128°) with 3-hydroxyphenanthrene-2-carboxylic acid (m. p. 298–300°) and 3-methoxyphenanthrene-2-carboxylic acid methyl ester (m. p. 133°, mixed melting point depression of 20°), with 3-hydroxyphenanthrene-4-carboxylic acid (m. p. 125°, dec.), and with 3-methoxyphenanthrene-10-carboxylic acid methyl ester (m. p. 93°), eliminates positions 2, 4, and 10. Of the positions 1, 5, 7, 8 remaining, we consider position 7 or 8 to be most probable for the location of the acetyl group. Lack of material, however, did not permit completion of the structural proof.

In attempts to synthesize the β-phenanthryl amines through the reaction sequence: $C_{14}H_9CHO \rightarrow C_{14}H_9CH{=}CHCOOH \rightarrow C_{14}H_9CH_2CH_2COOH \rightarrow$ Curtius' degradation $\rightarrow C_{14}H_9CH_2CH_2NH_2$, the yields of the intermediate products were very satisfactory, except those of the urethan derivatives (from the hydrazides). These experiments were finally abandoned, and the amines were prepared more successfully by electrolytic reduction of the β-nitro-α-phenanthrylethylenes.[4]

The β-phenanthrylacrylic acids and β-phenanthrylpropionic acids (2-, 3-, and 9-isomers) and some of their derivatives, which we prepared for the synthesis by the method first mentioned, were described recently by Bachmann and Kloetzel.[5] Their mode of preparation is essentially the same as ours.[6]

With the intention of preparing cyclic amino alcohols of types I and II, analogous to those described in foregoing papers,[7] but containing four benzene nuclei instead of three, we synthesized 4-

(1) The work reported in this paper is part of a unification of effort by a number of agencies having responsibility for the solution of the problem of drug addiction. The organizations taking part are: The Rockefeller Foundation, the National Research Council, the U. S. Public Health Service, the U. S. Bureau of Narcotics, the University of Virginia, and the University of Michigan.

(2) "Attempts to Synthesize Substances with Central Narcotic and, in Particular, Analgesic Action," Mosettig, Eddy, and co-workers, *U. S. Pub. Health Service Repts.*, Government Printing Office, Washington, D. C., in press.

(3) (a) Mosettig and Burger, THIS JOURNAL, **55**, 2981 (1933); (b) Burger and Mosettig, *ibid.*, **56**, 1745 (1934).

(4) Mosettig and May, unpublished results.

(5) Bachmann and Kloetzel, THIS JOURNAL, **59**, 2207 (1937).

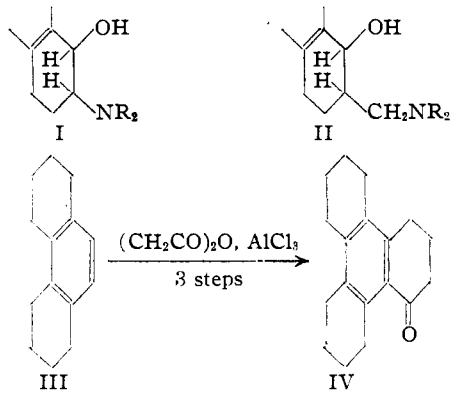
(6) Compare Burger and Mosettig, *ibid.*, **59**, 1306 (1937).

(7) (a) Mosettig and Burger, *ibid.*, **57**, 2189 (1935); (b) Burger and Mosettig, *ibid.*, **58**, 1570 (1936).

TABLE I

No.	Name of compound	Appearance	Solvent	Yield	M. p., °C.	Formula	Carbon, % Calcd.	Carbon, % Found	Hydrogen, % Calcd.	Hydrogen, % Found	Nitrogen, % Calcd.	Nitrogen, % Found
1	3-Phenanthroic acid dimethyl amide[a]	Shiny prisms	EtOH	Nearly quant.	120.5–121	$C_{17}H_{15}ON$					5.62	5.81
2	9-Phenanthroic acid dimethyl amide[b]	Needles	EtOH	Nearly quant.	182.5–183	$C_{17}H_{15}ON$					5.62	5.95
3	β-Diethylaminoethyl-3-phenanthroate HCl[c]	Needles	EtOH–Et_2O		202–202.5	$C_{21}H_{24}O_2NCl$	70.46	70.79	6.77	7.02		
4	Picrate	Yellow needles	EtOH		177.5–178	$C_{27}H_{26}O_9N_4$					10.17	9.77
5	β-Diethylaminoethyl-9-phenanthroate HCl[c]	Needles	EtOH–Et_2O		171–171.5	$C_{21}H_{24}O_2NCl$	70.46	70.49	6.77	6.66		
6	Picrate	Yellow needles	EtOH		144–145	$C_{27}H_{26}O_9N_4$					10.17	10.67
7	9-Aminomethylphenanthrene[d]	Silky needles	Pet. ether	Nearly quant.	108–108.5	$C_{15}H_{13}N$					6.77	6.95
8	Hydrochloride	Leaflets	EtOH–Et_2O		292–294, dec.	$C_{15}H_{14}NCl$		Chlorine	14.56	14.74	5.75	5.89
9	3-ω-Isonitrosoacetylphenanthrene[e]	Faintly yellow plates	AcOEt	40–45	272–273							
10	3-(2-Amino-1-oxo-ethyl)-phenanthrene HCl[f]	Plates	H_2O	60	260–320, dec.	$C_{16}H_{14}ONCl$		Chlorine	13.06	13.27		
11	Picrate	Orange plates	EtOH		193 dec.	$C_{22}H_{16}O_8N_4$					12.07	12.12
12	3-(2-Amino-1-hydroxy-ethyl)-phenanthrene HCl[g]	Plates	EtOH		235–236, dec.	$C_{16}H_{16}ONCl$					5.12	5.38
13	Picrate	Yellow plates	EtOH		218.5–219.5	$C_{22}H_{18}O_8N_4$					12.02	12.13
14	3-(2-Amino-1-hydroxy-ethyl)-phenanthrene[h]	Diamonds			139–139.5	$C_{16}H_{15}ON$	80.97	80.81	6.38	6.37	5.91	6.00
15	2-ω-Isonitrosoacetylphenanthrene[i]	Faintly yellow plates	AcOEt	30	175–176, dec.							
16	2-(2-Amino-1-oxo-ethyl)-phenanthrene HCl[j]	Needles	H_2O	60	280–310, dec.	$C_{16}H_{14}ONCl$		Chlorine	13.06	13.23		
17	Picrate	Orange prisms	EtOH		185–189, dec.	$C_{22}H_{16}O_8N_4$					12.07	12.17
18	2-(2-Amino-1-hydroxy-ethyl)-phenanthrene[h]	Leaflets			143–144	$C_{16}H_{15}ON$	80.97	80.74	6.38	6.43	5.91	6.06
19	Hydrochloride	Diamond-shaped leaflets	EtOH		251–254, dec.	$C_{16}H_{16}ONCl$					5.12	5.28
20	Picrate	Orange needles	EtOH		205–206, dec.	$C_{22}H_{18}O_8N_4$					12.02	12.21
21	3-[2-(Diethylamino)-1-acetoxy-ethyl]-phenanthrene HCl[k]		EtOH–Et_2O		221–221.5	$C_{23}H_{26}O_2NCl$	71.03	71.01	7.05	7.14		
22	3-(1,2,3,4-Tetrahydroisoquinolino)-4-hydroxy-1,2,3,4-tetrahydrophenanthrene[l]	Shiny leaflets	EtOH		125–126	$C_{23}H_{23}ON$	83.84	83.98	7.04	6.43		
23	3-(1,2,3,4-Tetrahydroisoquinolino)-4-acetoxy-1,2,3,4-tetrahydrophenanthrene[m]		EtOH–H_2O	30	123–125	$C_{25}H_{25}O_2N$	80.82	81.12	6.79	6.78		
24	Hydrochloride		EtOH–Et_2O		200–201, dec.	$C_{25}H_{26}O_2NCl$					3.44	3.56
25	3-Hydroxy-6-[2-(diethylamino)-1-acetoxy-ethyl]-phenanthrene HCl[n]		EtOH–Et_2O	20–30	199–201	$C_{22}H_{26}O_3NCl$	68.10	67.86	6.76	6.93		
26	3-Acetoxy-6-[2-(diethylamino)-1-acetoxy-ethyl]-phenanthrene HCl[o]		EtOH–Et_2O	80–90	201–202	$C_{24}H_{28}O_4NCl$	67.02	67.20	6.57	6.54		
27	3-[2-(1,2,3,4-Tetrahydroisoquinolino)-1-oxoethyl]-phenanthrene HCl[p]	Plates	EtOH	40	246–248, dec.	$C_{25}H_{22}ONCl$					3.62	3.58
28	3-[2-(1,2,3,4-Tetrahydroisoquinolino)-1-hydroxy-ethyl]-phenanthrene HCl[q]		EtOH–Et_2O	81	198–199, dec.	$C_{25}H_{24}ONCl$	77.00	76.19	6.21	6.59		
29	Picrate		EtOH		180–181.5	$C_{31}H_{26}O_9N_4$					9.62	9.69
30	3-Acetoxy-x-acetylphenanthrene[r]		MeOH	1	124–125	$C_{18}H_{14}O_3$	77.67	77.74	5.07	4.98		
31	3-Hydroxy-x-acetylphenanthrene[s]	Pale yellow	Dil. EtOH		237–238	$C_{16}H_{12}O_2$	81.35	81.26	5.13	5.30		
32	3-Methoxy-x-acetylphenanthrene[t]	Felted needles	Dil. MeOH		93–94	$C_{17}H_{14}O_2$	81.56	81.39	5.64	5.86		
33	3-Methoxyphenanthrene-x-carboxylic acid[u]	Prisms	Toluene		220–223, dec.	$C_{16}H_{12}O_3$	76.16	76.55	4.80	4.81		
34	3-Hydroxyphenanthrene-x-carboxylic acid[v]		Xylene		(270) 281–284, dec.							
35	3-Methoxyphenanthrene-x-carboxylic acid methyl ester[w]	Nearly colorless fine needles	MeOH		127.5–128	$C_{17}H_{14}O_3$	76.66	75.98	5.30	5.47		
36	β-(2-Phenanthryl)-propionic acid hydrazide[x]	Plates	EtOH		164–165	$C_{17}H_{16}ON_2$					10.61	10.67
37	β-(3-Phenanthryl)-propionic acid hydrazide[x]	Plates	EtOH		189–190	$C_{17}H_{16}ON_2$					10.61	10.81
38	β-(3-Phenanthryl)-propionic acid amide[y]	Leaflets	MeOH		161.5–162	$C_{17}H_{15}ON$					5.62	5.69
39	β-[9-(1,2,3,4,5,6,7,8-Octahydrophenanthroyl)]-propionic acid[z]	Blades	EtOH	86	143–144	$C_{18}H_{22}O_3$	75.46	75.98	7.76	7.92		
40	γ-[9-(1,2,3,4,5,6,7,8-Octahydrophenanthryl)]-butyric acid[aa]	Plates			128–129	$C_{18}H_{24}O_2$	79.36	78.94	8.89	8.96		
41	4-Keto-dodecahydrotriphenylene[bb]	Needles	EtOH		222–222.5	$C_{18}H_{22}O$	84.98	85.29	8.72	8.76		

keto-dodecahydrotriphenylene IV, from *sym*-octahydrophenanthrene III.



The same cyclic ketone was obtained by chromic acid oxidation of dodecahydrotriphenylene, which itself was prepared by the method of Mannich[8] from cyclohexanone. The identity of the two ketones proves the structure of our cyclic ketone as well as of Mannich's dodecahydrotriphenylene, since both ketones could be reduced to this hydrocarbon. A similar sequence of reactions, starting from phenanthrene, was carried out recently by Bergmann and Blum-Bergmann[9] with the structural proof of triphenylene and a preparative access to this hydrocarbon and its alkyl and aryl derivatives in view.

Experimental

[a] To a solution of 5 g. of 3-phenanthroic acid chloride in 35 cc. of benzene, was added 15 cc. of a 22% solution of dimethylamine. The dimethyl amide began to precipitate immediately, first as a finely divided oil, which turned soon into a crystalline mass.

[b] Prepared analogously to No. 1. Instead of benzene, acetone was used as a solvent. Moderately soluble in alcohol, may be purified also by sublimation in an oil-pump vacuum.

[c] Five grams of the respective (3 or 9)-phenanthroyl chloride and 6 g. of β-diethylaminoethyl alcohol were heated in 20 cc. of dry chloroform on a steam-bath for one hour. The reaction mixture was diluted with ether and shaken with dilute aqueous potassium hydroxide solution. The oily base obtained from the ethereal solution was converted into the hydrochloride and picrate in the customary way.

[d] Five grams of 9-cyanophenanthrene, dissolved in 60 cc. of glacial acetic acid, was hydrogenated, using platinum oxide (0.1 g.) as catalyst. The hydrogen absorption took place very slowly, but came to a standstill when the required amount of hydrogen was taken up. The catalyst was filtered off and the solution diluted with water, made alkaline, and extracted with ether.

[e] Method of Claisen and Manasse [*Ber.*, **20**, 2194 (1887)]. Ten and three-tenths grams of butyl nitrite and 22 g. of 3-acetylphenanthrene were added to a solution of 2.3 g. of sodium in 50 cc. of absolute alcohol. This mixture was shaken at room temperature for forty-eight hours, diluted with water, and extracted with ether. The aqueous layer was acidified with acetic acid and warmed on the steam-bath for fifteen minutes. Practically the same results were obtained when amyl nitrite was used instead of butyl nitrite.

[f] Method of Rupe [*Ber.*, **28**, 254 (1895)]. To a suspension of 10 g. of No. 9 in 200 cc. of alcohol, 46 g. of stannous chloride in 70 cc. of concd. hydrochloric acid and a trace of tin were added. The mixture was warmed on a steam-bath for two hours and then allowed to stand at room temperature for two days. The precipitate was filtered (sintered glass filter), washed with a little alcohol and ether, suspended in water, and heated to boiling while hydrogen sulfide was passed in. The amino ketone hydrochloride precipitated from the filtrate after concentration or addition of concd. hydrochloric acid.

[g] One part of No. 10 in 50 parts of alcohol was reduced in the presence of platinum oxide (0.1 part).

[h] Purified by sublimation in an oil-pump vacuum.

[i] To a solution of 5.8 g. of sodium in 110 cc. of absolute alcohol were added 29.3 g. of amyl nitrite and 55 g. of 2-acetylphenanthrene. The mixture was shaken at room temperature for three days and worked up as in the case of the 3-isomer. Thirty-two grams of unchanged 2-acetylphenanthrene was recovered.

[j] The reduction of the isonitroso ketone was carried out as in the case of the 3-isomer.

[k] Two grams of 3-[2-(diethylamino)-1-hydroxy-ethyl]-phenanthrene [Mosettig and van de Kamp, THIS JOURNAL, **55**, 3448 (1933)], was heated with 6 cc. of acetic anhydride at 80–90° for four hours. The base is oily.

[l] Prepared by liberation from the corresponding sparingly soluble hydrochloride[7a] with sodium hydroxide solution and extraction with chloroform or ether. The oily base was induced to crystallize by triturating it with ethyl acetate and petroleum ether. The crystalline acetate (B–CH_3COOH) is obtained by dissolving the base in ether and adding glacial acetic acid. It is soluble in ether and melts at 118–122°. It dissolves readily in water, but hydrolyzes when allowed to stand for some time, or when heated; the solid salt also decomposes gradually.

[m] No. 22 was treated at room temperature with pyridine and acetic anhydride for twenty-four hours. Mixed melting point of No. 22 and No. 23: 95–110°.

[n] A solution of 1 g. of 3-hydroxy-6-[2-(diethylamino)-1-hydroxyethyl]-phenanthrene hydrochloride (A) in 10 cc. of dry pyridine and 3 cc. of acetic anhydride was allowed to stand for twenty-four hours at room temperature. The solution was evaporated in a vacuum to dryness, and the residue was digested with sodium bicarbonate solution. The free base was extracted with ether and converted into the hydrochloride. Improvement of the preparation of A (see ref. 3b). Twenty grams of the perchlorate of 3-acetoxy-6-[2-(diethylamino)-1-oxo-ethyl]-phenanthrene suspended in 200 cc. of methanol was hydrogenated using 0.3 g. of platinum oxide catalyst. The calculated amount of hydrogen was taken up within ten to

(8) Mannich, *Ber.*, **40**, 153 (1907).

(9) Bergmann and Blum-Bergmann, THIS JOURNAL, **59**, 1441 (1937).

thirty hours in different experiments. The catalyst was filtered from the clear solution and the solvent was evaporated in a vacuum. The oily perchlorate of the 3-acetoxy-6-[2-(diethylamino)-1-hydroxy-ethyl]-phenanthrene (m. p. of hydrochloride, 173–174°) was boiled with 750 cc. of 2% sodium hydroxide solution. The alkaline solution was acidified and made ammoniacal. The free base was extracted with chloroform and purified through the hydrochloride. After distillation in an oil-pump vacuum or recrystallization from ether–petroleum ether, it melts at 124.5–125.5°. The presence of the free phenolic hydroxyl in No. 25 can be demonstrated readily. The aqueous, ice cold solution of No. 25 gives, with a few drops of dilute sodium hydroxide solution, a milky precipitate, which is readily dissolved by further addition of sodium hydroxide. From this solution the unchanged base (oily) may be recovered by immediate precipitation with ammonium chloride and extraction with ether. (No change in m. p. of the hydrochloride.)

[o] One gram of A was boiled under reflux with 10 cc. of acetic anhydride and 1 g. of anhydrous sodium acetate for five hours. The cooled mixture was poured into water. The oily base was obtained by making the solution alkaline with sodium bicarbonate and extracting it with ether. Mixed melting point of No. 25 and No. 26, 177–192°. The aqueous solution of No. 26 gives, with a few drops of dilute sodium hydroxide solution, a milky precipitate, which is not dissolved by further addition of sodium hydroxide. However, within twenty to thirty minutes, the precipitate goes completely into solution. No. 26 is also obtained by acetylation of No. 25 with acetic anhydride and sodium acetate.

[p] An ethereal solution of 1.5 g. of 3-ω-bromoacetylphenanthrene and 1 g. of 1,2,3,4-tetrahydroisoquinoline was allowed to stand at room temperature for twenty hours. The yellow crystalline precipitate was filtered, washed with ether and then with water. From the ethereal filtrate only oily brown materials were obtained. The crystalline precipitate was warmed with 1 *N* sodium hydroxide solution to 50° for ten minutes. The free base (0.9 g. of brown crystals) was converted to the hydrochloride in acetone solution with alcoholic hydrogen chloride.

[q] The amino ketone hydrochloride was reduced catalytically (platinum oxide, 80% methanol).

[r] The crude 3-acetoxyphenanthrene obtained by boiling 350 g. of 3-hydroxyphenanthrene with acetic anhydride was subjected to the Friedel–Crafts reaction under the previously described conditions. Two hundred and fifty-four grams of 3-acetoxy-6-acetylphenanthrene (m. p. 152–155°) was obtained. The alcoholic mother liquors of this ketone were evaporated to dryness and completely acetylated with acetic anhydride in pyridine solution. The oily reaction product was treated with semicarbazide hydrochloride and sodium acetate. Only a relatively small amount of crystalline semicarbazone could be isolated. The oily ketone obtained by boiling of the semicarbazone with 10% aqueous hydrochloric acid was reacetylated with acetic anhydride in pyridine solution. The 3-acetoxy-*x*-acetylphenanthrene so obtained was purified by distillation in an oil-pump vacuum.

[s] Obtained from No. 30 by short boiling with aqueous potassium hydroxide solution.

[t] Prepared from No. 31 by methylation with an excess of diazomethane in methyl alcohol–ether solution. The methylation was slow and stopped when about 60% of the hydroxy compound was methylated. The unchanged hydroxy ketone was removed by repeated extraction with dilute aqueous sodium hydroxide solution. Purification was accomplished by sublimation in an oil-pump vacuum and recrystallization. The mixed melting point with 3-methoxy-9-acetylphenanthrene of m. p. 98° showed a depression of about 25°.

[u] One gram of No. 32 was boiled for three hours with 180 cc. of a 0.5% sodium hypochlorite solution (prepared from H. T. H. bleaching powder with sodium carbonate) containing 1 cc. of 10% sodium hydroxide solution. Some insoluble material was filtered out of the cooled solution, and some sodium bisulfite was added, followed by acidification with hydrochloric acid. The carboxylic acid was purified by reprecipitation from sodium carbonate solution and recrystallization.

[v] No. 33 was boiled for three hours with a mixture consisting of 1 part of 48% aqueous hydrobromic acid and 1 part of glacial acetic acid. The solution was poured into water whereupon the hydroxy acid precipitated as a yellow powder. When mixed with 3-hydroxyphenanthrene-2-carboxylic acid (of m. p. 298–300°, dec.) it melted at 265–270° dec.).

[w] One-tenth of a gram of No. 34 was boiled with 3 cc. of methyl iodide and 2 g. of silver oxide in 10 cc. of benzene for six hours. The resulting benzene solution was extracted with sodium bicarbonate and evaporated. The remaining methoxycarboxylic ester was purified by distillation and crystallization. The mixed m. p. with 3-methoxy-2-carboxylic acid methyl ester (of m. p. 133°) was 100–110°. One-tenth of a gram of No. 33 was boiled under reflux with 5 cc. of quinoline and 0.1 g. of copper-bronze for twenty-five minutes. The mixture was cooled, diluted with ether, filtered, and extracted first with dilute sulfuric acid and then with sodium bicarbonate solution. The oily residue from the dried ether solution was distilled in an oil-pump vacuum and recrystallized from methanol; colorless crystals, m. p. 56–57°. The mixed m. p. with 3-methoxyphenanthrene (of m. p. 58–59°) was at 57–58°.

[z] Prepared by boiling for seven hours a mixture of 2.5 g. of the methyl or ethyl ester of the corresponding β-phenanthrylpropionic acids, 5 cc. of hydrazine hydrate, and 5 cc. of alcohol. The β-phenanthrylpropionic acids were prepared in quantitative yields by catalytic hydrogenation of the corresponding acrylic acid derivatives (alcoholic solution or suspension, platinum oxide).

[y] Prepared by saturating a suspension of β-(3-phenanthryl)-propionic acid methyl ester in 10 parts of methyl alcohol at 0° with ammonia, and heating the mixture in a pressure bottle at 100° for twenty hours.

[z] To an ice-cold mixture of 18.6 g. of *sym*-octahydrophenanthrene, 12 g. of succinic anhydride, and 200 cc. of carbon disulfide, 27.6 g. of aluminum chloride was added in small portions in the course of thirty minutes. The mixture was kept between 0–5° for four hours and then allowed to warm up to room temperature. Finally, after eight hours, the reaction mixture was poured onto ice, and worked up in the customary way.

[aa] A mixture of 1 part of No. 39, 5 parts of amalgamated

zinc, and 5 parts of concd. hydrochloric acid was boiled for twenty-four hours. The butyric acid was purified conveniently by recrystallization of its sodium salt from water. The free acid may be purified by sublimation.

[bb] I. A mixture of 1 g. of No. 40, 3 cc. of concd. sulfuric acid, and 1 cc. of water was heated at 100° for one hour. When the reaction mixture was poured into water, a crystalline precipitate formed, which was dissolved in ether. The ether solution was extracted with dilute alkali, and yielded on evaporation 0.7 g. of practically pure ketone. For further purification the ketone may be recrystallized from alcohol or sublimed in an oil-pump vacuum.

II. A mixture of 1 g. of dodecahydrotriphenylene (prepared according to Mannich) and 1 g. of chromic acid in 2 cc. of 80% acetic acid was allowed to stand at room temperature for five hours and then poured into water. The precipitated ketone was purified by recrystallization from alcohol and by vacuum sublimation, m. p. 221.5–222.5°. The mixed melting point with the ketone obtained by ring closure of the octahydrophenanthrylbutyric acid was 221–222°. (The mixed m. p. with dodecahydrotriphenylene was 214–217°.)

A mixture of 1 g. of No. 41, 5 g. of amalgamated zinc, and 5 cc. of concd. hydrochloric acid was boiled under reflux for eighteen hours. The hydrocarbon was isolated as a white crystalline mass and melted, after vacuum sublimation, at 226–228°. Dodecahydrotriphenylene prepared according to Mannich[8] melts, after crystallization from ethanol and vacuum sublimation, at 226–229°.

Summary

A number of scattered and disconnected experiments in the phenanthrene series is described.

These experiments include the preparation of amides and β-amino ethyl esters of phenanthroic acids, the preparation of amino alcohols of the type $C_{14}H_9CHOHCH_2NR_2$ and the synthesis of 4-ketododecahydrotriphenylene.

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[CONTRIBUTION FROM THE GEORGE HERBERT JONES LABORATORY OF THE UNIVERSITY OF CHICAGO]

A Convenient Preparation of Volatile Acid Chlorides

BY HERBERT C. BROWN

The usual procedure for the preparation of organic acid chlorides involves the action of an inorganic acid chloride upon an organic acid. Among the chlorides which have been used are silicon tetrachloride, the sulfur chlorides, phosphorus tri- and pentachlorides, and thionyl chloride. However, only the phosphorus chlorides and thionyl chloride have been widely adopted in the laboratory.

The possibility of utilizing organic acid chlorides for the preparation of other acid chlorides has been neglected for the most part. Adams and Ulich[1] have reported that they could obtain almost quantitative yields of acid chlorides by the action of oxalyl chloride on organic acids. The cost and instability of the reagent, however, preclude the general adoption of this procedure. Van Dorp and Van Dorp[2] found that they could obtain fumaryl chloride by the action of phthalyl chloride on fumaric acid. This method has been extended lately by Kyrides,[3] who confirms the above preparation and reports the preparation of butyryl chloride in 90% yield. Further, the action of chloroacetyl chloride on acetic acid has been utilized for the preparation of acetyl chloride.[4]

(1) Adams and Ulich, THIS JOURNAL, **42**, 599 (1920).
(2) Van Dorp and Van Dorp, *Rec. trav. chim.*, **25**, 96 (1906).
(3) Kyrides, THIS JOURNAL, **59**, 206 (1937).
(4) U. S. Patent 1,850,205 (1932).

In the course of an investigation now being conducted the need for a large number of volatile acid chlorides led to the development of a simple procedure for their preparation, involving the action of a relatively slightly volatile acid chloride upon an organic acid. Because of its cheapness and availability, benzoyl chloride was selected as the non-volatile acid chloride. The procedure is very simple: the acid is mixed with an excess of benzoyl chloride and the acid chloride desired is distilled through a small column directly out of the reaction mixture. The reaction is general, limited only by the volatility of the acid chloride—it has given excellent results with all the lower fatty acids, saturated, unsaturated, and their halogen derivatives, which have been tested.

Other advantages of the new method are its rapidity (an average preparation can be completed in one hour) and its economy (benzoyl chloride is much cheaper than either thionyl chloride or phosphorus pentachloride). If it is desired, benzoic acid can be recovered easily in high yield from the residue.

Experimental

1. Apparatus and Materials.—The fractionating column used was 25 cm. in length. The inner tube (9 mm.) was packed with a spiral containing 2 turns per cm. made from no. 18 tantalum wire. The flasks were fitted to the