

gave fine white needles, m.p. 193–194° dec.,  $[\alpha]^{20}_D +18^\circ$  (c 1, water). Mixed with natural I, the m.p. was 193–194° dec. The infrared spectra of both natural and synthetic I were measured as micro-mulls in purified mineral oil and no significant differences were noted.

The DL-form of I was prepared in the same manner, starting with phthaloyl-DL-glutamic acid anhydride. The prod-

uct was obtained in the form of glistening colorless platelets, m.p. 191–192° dec.<sup>22</sup>

Anal. Calcd. for  $C_{16}H_{12}O_2N_2$ : N, 21.10. Found: N, 21.04, 21.22.

(22) Bath preheated to 180°.

MADISON, WISCONSIN

[CONTRIBUTION NO. 142 FROM THE GENERAL LABORATORIES OF THE UNITED STATES RUBBER COMPANY]

## Some *meso*-Substituted Anthracenes. I. 9,10-Bis-(chloromethyl)-anthracene as a Synthetic Intermediate<sup>1</sup>

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An improved procedure for the preparation of 9,10-bis-(chloromethyl)-anthracene (I) is reported. Compounds prepared by displacement reactions from I are described as well as certain more remote derivatives.

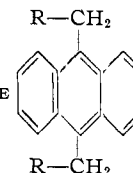
The chloromethylation of anthracene has been developed so that good yields of 9,10-bis-(chloromethyl)-anthracene (I) can be obtained conveniently. This has permitted the synthesis of a new series of *meso*-substituted anthracenes by displacement reactions from I and by further transformations. For example, it has been possible to prepare for the first time 9,10-anthracenediacetic acid XVI although the lower and higher homologs have long been known.

Ethers VIII, IX derived from I are, like benzyl ethers, sensitive toward acids. Because they are more soluble and less irritating, they can profitably be substituted for I in certain acidic reactions.

Previous attempts to prepare the diamine II by inconvenient routes<sup>5,6</sup> were not successful, and the correct analysis and physical properties have never been reported. It is possible to prepare this amine in good yields merely by enclosing I with anhydrous ammonia in a rocked autoclave, a method similar to

TABLE I

COMPOUNDS DERIVED FROM 9,10-BIS-(CHLOROMETHYL)-ANTHRACENE



R =							
I	Cl	VII	OCOCH <sub>3</sub>	XIII	SCH <sub>2</sub> CH <sub>2</sub> CN	XIX	CH <sub>2</sub> COOH
II	NH <sub>2</sub>	VIII	OCH <sub>3</sub>	XIV	CN	XX	CH <sub>2</sub> COOCH <sub>3</sub>
III	NH <sub>2</sub> ·HCl	IX	OC <sub>2</sub> H <sub>5</sub>	XV	CONH <sub>2</sub>	XXI	CH <sub>2</sub> CONH <sub>2</sub>
IV	NHCOCH <sub>3</sub>	X	SH	XVI	COOH	XXII	CH <sub>2</sub> CH <sub>2</sub> OH
V	NCO	XI	SCOCH <sub>3</sub>	XVII	COOCH <sub>3</sub>		
VI	OH	XII	SCH <sub>2</sub> COOCH <sub>3</sub>	XVIII	CH <sub>2</sub> OH		

All of the compounds listed in Table I are intrinsically yellow although anthracene is colorless except for a blue-violet fluorescence. Solubilities vary widely with substituent groups. Thus 9,10-anthracenedimethanethiol (X) is quite soluble in common organic solvents, while 9,10-anthracenedimethanol (VI) dissolves only in certain high-boiling, polar solvents such as nitrobenzene or anisole.

The parent compound I of this series has been known for some time,<sup>2-4</sup> but a satisfactory and detailed procedure for its preparation has never been published. It is crystalline, melts with decomposition and is slightly soluble in most organic solvents but recrystallizable from toluene or dioxane. It is a skin irritant capable of causing acute sensitization, and should be handled with care.

(1) Part of this work was done under contract NOBS-55413 with the Bureau of Ships, Department of the Navy.

(2) I. G. Farbenindustrie, German Patent 533,850; *Chem. Zentr.*, **104**, I, 2396 (1931).

(3) I. Ia. Postovskii and N. P. Bednyagina, *J. Gen. Chem. U.S.S.R.*, **7**, 2919 (1937).

(4) G. M. Badger and J. W. Cook, *J. Chem. Soc.*, 802 (1939).

that mentioned for the conversion of 9-chloromethylphenanthrene to the corresponding amine.<sup>7</sup> Treatment of the stable dihydrochloride III with phosgene gives 9,10-anthracenedimethyl isocyanate (V).

While it may be possible to convert I directly to 9,10-anthracenedimethanol (VI), the glycol can be prepared in excellent yields through the diacetate. This diacetate was prepared either by treatment of I with potassium acetate,<sup>4</sup> or by treating the ether IX with acetic acid and a trace of mineral acid.

The dithiol X was prepared through the diisothio-urionium chloride. An earlier attempt to prepare this dithiol gave material, m.p. 145° (s.130°) with no analysis reported.<sup>8</sup> The present procedure leads to good yields of X, m.p. 217–218° (s.216°), with correct analysis and suitable derivatives.

(5) P. De Bruyn, *Compt. rend.*, **231**, 295 (1950).

(6) W. Herzberg and H. Lange, German Patent 442,774.

(7) J. von Braun, *Ber.*, **70B**, 979 (1937).

(8) P. O. Tawney, U. S. Patent 2,583,975.

Alkaline hydrolysis of 9,10-anthracenediacetonitrile (XIV) yielded 9,10-anthracenediacetic acid (XVI). Acid hydrolysis of the nitrile gave another product, and this reaction will be discussed in a later paper.

Recently several of the compounds listed in Table I, namely, VI, VIII, XIV and XVI, were mentioned without experimental evidence other than melting points.<sup>9</sup> In the case of XVI we note a discrepancy in the melting point of our compound (310–315° dec.) and the one reported by the French authors (407–409°).

Many of the compounds in Table I react with dienophiles. We plan to report several of these reactions later.

#### Experimental<sup>10,11</sup>

**9,10-Bis-(chloromethyl)-anthracene<sup>12</sup> (I).**—A mixture of 3600 ml. of dioxane and 600 ml. of concentrated hydrochloric acid was saturated with hydrogen chloride gas. Then 450 g. (2.34 moles) of 90–95% anthracene and 380 g. of 95% paraformaldehyde were added. The mixture was stirred slowly and heated to incipient reflux while a fine dispersion of hydrogen chloride gas was introduced for two hours. After stirring slowly at gentle reflux three hours longer, heating was stopped and the mixture allowed to stand 16 hours. The fine granular yellow solid was removed by filtration. Two resuspensions in two different 500-ml. portions of fresh dioxane with stirring and subsequent filtration, followed by a third washing with 800 ml. of fresh dioxane on the filter and thorough drying gave 415 g. (65%) of crude material, m.p. 253–255° dec.

This material is adequate for most purposes, but two recrystallizations from toluene with an intervening hot filtration, followed by thorough removal of solvent at reduced pressure gave yellow blades, m.p. 258–260° dec.

**9,10-Anthracenedimethylamine (II).**—To 30.0 g. (0.109 mole) of I, m.p. 255–260°, in a one-liter steel bomb, which was cooled in a Dry Ice-carbon tetrachloride-bath, was added 500 ml. of anhydrous ammonia. A few 1/4" stainless steel ball-bearings were added to pulverize the solid phase, and the bomb sealed and rocked at ambient temperatures (20–27°) for four days. The bomb was cooled and the contents digested with 180 g. of concentrated hydrochloric acid in 500 g. of water. After filtration the slight residue was washed with a little warm water, and the total acidic filtrate poured into 150 g. of sodium hydroxide in 500 ml. of water. The finely divided yellow amine was removed by filtration and washed with water. The crude, dry product weighed 25.1 g. (97%), m.p. 222–228° (s. 217°).

Partial purification was achieved through the dihydrochloride III, as follows: A 20-g. sample of diamine was stirred with 20 ml. of concentrated hydrochloric acid in 200 ml. of water (about 1 N) and the solution filtered. Addition of 20 ml. of concentrated hydrochloric acid to the filtrate precipitated III. After two repetitions of this technique an aliquot was neutralized, washed, and dried. The diamine so obtained melted from 229–235°.

Diamine II purified in this way was sublimed once at 190–210° (0.3 mm.) to give bright yellow blades, m.p. 238–240° (s. 230°).

*Anal.* Calcd. for C<sub>16</sub>H<sub>16</sub>N<sub>2</sub>: C, 81.32; H, 6.83; N, 11.86. Found: C, 81.52; H, 6.87; N, 11.83.

**N,N'-Diacetyl-9,10-anthracenedimethylamine (IV).**—A mixture of 2.0 g. II and 40 ml. of acetic anhydride was refluxed two hours. After cooling, the yellow solid was removed by filtration, washed with hot water and dried; crude yield 2.68 g. (98%), m.p. 370–390° dec. Two recrystallizations from dimethylformamide, followed by pumping at 100° (0.3 mm.) over potassium hydroxide pellets for 60 hours, gave pale yellow prisms of IV, m.p. 395–400° dec.

(9) G. Rio, *Compt. rend.*, **236**, 496 (1953).

(10) All melting points were determined on a calibrated Kofler micro hot-stage, and are accurate within ±1°.

(11) All analyses were carried out by the Schwarzkopf Laboratories, Woodside, L. I., N. Y.

(12) 9,10-Bis-(chloromethyl)-anthracene is a severe skin-irritant, causing rashes and sensitization. The solid, solutions and vapors from its solutions should be handled with extreme care.

*Anal.* Calcd. for C<sub>20</sub>H<sub>20</sub>N<sub>2</sub>O<sub>2</sub>: C, 74.97; H, 6.29; N, 8.75. Found: C, 75.20; H, 6.52; N, 8.94.

**9,10-Anthracenedimethyl Isocyanate (V).**—A 5.0-g. (0.016 mole) sample of III was suspended in 150 ml. of *o*-dichlorobenzene and the stirred suspension was heated to reflux, then phosgene gas was introduced through a coarse fritted glass inlet tube as fast as it could be absorbed. Within two hours all solid had dissolved, and after another hour heating and phosgene addition were discontinued, and dry nitrogen gas was bubbled through the mixture as it cooled. Filtration gave 1.25 g. of crude V, m.p. 210–212°. Concentration of the filtrate at 50° (9 mm.) gave 3.20 g., m.p. 205–210° (total crude yield 95%); sublimation gave 4.2 g. of yellow crystals, m.p. 210–212°. A sample of V purified for analysis by recrystallization from toluene, followed by sublimation at 195–200° (0.7 mm.), consisted of bright yellow blades, m.p. 214–215°.

*Anal.* Calcd. for C<sub>18</sub>H<sub>14</sub>O<sub>2</sub>N<sub>2</sub>: C, 74.99; H, 4.20; N, 9.72. Found: C, 74.84; H, 4.03; N, 9.46.

**9,10-Anthracenedimethanol (VI).**—To 10.2 g. (0.032 mole) of VII in 800 ml. of methanol was added 30.0 g. of 85% potassium hydroxide. After two hours reflux and stirring, the reaction mixture was poured into 1 l. of cold water, and the yellow precipitate removed by filtration and washed with water until the washings were neutral. The dry, crude glycol weighed 7.4 g. (98%), m.p. 258–270°. A sample of VI purified for analysis by recrystallization from anisole followed by desiccation over paraffin chips at 0.5 mm. for four days consisted of bright yellow leaflets, m.p. 287–289° (s. 280°). Nitrobenzene also was a good recrystallization solvent.

*Anal.* Calcd. for C<sub>16</sub>H<sub>14</sub>O<sub>2</sub>: C, 80.65; H, 5.92. Found: C, 80.84; H, 5.83.

**9,10-Anthracenedimethanol Diacetate (VII) by Acid Cleavage of 9,10-Anthracenedimethanol Diethyl Ether (IX).**—To a mixture of 50 ml. of acetic acid and 1 ml. of concentrated sulfuric acid was added 2.0 g. (0.007 mole) of IX, m.p. 140–142°, with heating and stirring. The ether dissolved rapidly to give a green solution, but within a few minutes a slurry of crystals reappeared. Filtration and drying gave 1.8 g., m.p. 217–221°. Concentration of the filtrate gave 0.3 g. with the same melting point (total crude yield 2.1 g. or 95%). Recrystallization from 2-butanone gave yellow needles of VII, m.p. 224–225°.

The same compound has been prepared by treatment of I with freshly fused potassium acetate in acetic acid.<sup>4</sup> By this method we obtained a 93% yield of VII, m.p. 224–225° (s. 222°). A mixture of the samples prepared by the two methods melted at 224–225° (s. 222°).

**9,10-Anthracenedimethanol Dimethyl Ether (VIII).**—A mixture of 80 ml. of methanol, 5.5 g. (0.02 mole) of I and 5.3 g. of 85% potassium hydroxide was refluxed one hour and 20 minutes. On cooling the methanol solution, 3.7 g. (70%) of the light-yellow solid separated. After a nearly quantitative recrystallization from methanol the melting point was 181–183°. A sample of VIII purified for analysis by recrystallization from dioxane and sublimation at 170° (1 mm.) melted at 183–185°.

*Anal.* Calcd. for C<sub>18</sub>H<sub>18</sub>O<sub>2</sub>: C, 81.16; H, 6.82. Found: C, 80.82; H, 6.60.

**9,10-Anthracenedimethanol Diethyl Ether (IX).**—A 5.5-g. quantity of 85% potassium hydroxide was dissolved in 200 ml. of absolute ethanol. Then 5.5 g. (0.02 mole) of I was added, and the mixture stirred and refluxed one hour. The suspension was filtered hot, and the filtrate chilled. A yellow solid precipitated and was removed by filtration and dried to give 3.2 g. (54%), m.p. 140–142°. Recrystallization from a mixture of water and ethylene glycol dimethyl ether, and subsequent sublimation at 130° (0.2 mm.) gave straw-colored, greasy platelets of IX, m.p. 139–141°.

*Anal.* Calcd. for C<sub>20</sub>H<sub>22</sub>O<sub>2</sub>: C, 81.50; H, 7.53. Found: C, 81.69; H, 7.50.

**9,10-Anthracenedimethanethiol (X).**—A suspension of 28.5 g. (0.104 mole) of I, m.p. 253–255° dec., and 17.0 g. of thiourea in 100 ml. of dioxane was refluxed for almost one hour. The bis-isothiuronium chloride was removed by filtration, suspended in 600 ml. of 20% sodium hydroxide solution, and refluxed with stirring ten hours. Then 600 ml. of hot water was added and reflux continued two hours longer. After filtration through a heated funnel, the filtrate deposited yellow plates of the sodium salt of the di-

thiol. This salt was isolated by filtration, dissolved in 500 ml. of water, and acidified with 50% sulfuric acid. The crude dithiol was filtered and dried to give 22.4 g. (80%), m.p. 210–217°. Recrystallization from pure dioxane<sup>13</sup> gave X as intensely yellow prisms, m.p. 217–218°.

*Anal.* Calcd. for  $C_{18}H_{14}S_2$ : C, 71.1; H, 5.2; S, 23.7. Found: C, 71.5; H, 5.4; S, 23.0.

**9,10-Anthracenedimethanethiol Diacetate (XI).**—A 4.4-g. (0.016 mole) sample of X, m.p. 217–218° (s.216°), was refluxed in 100 ml. of acetic anhydride for 45 minutes. The solution was cooled, and a solid, less intensely yellow than the dithiol, crystallized. This solid was removed by filtration and the filtrate concentrated to give a second crop. The total crude yield was 4.6 g. (81%), m.p. 210–216°. A sample twice recrystallized from ethyl acetate (with one hot filtration), and pumped at 60° (0.3 mm.) for 18 hours consisted of pale golden crystals of XI, m.p. 212–215° (s.209°).

*Anal.* Calcd. for  $C_{20}H_{18}O_4S_2$ : C, 67.76; H, 5.12; S, 18.09. Found: C, 67.79; H, 5.37; S, 18.08.

**Dimethyl 9,10-Anthracene-bis-4'-(3'-thiobutyrate) (XII).**—A mixture of 5.8 g. (0.02 mole) of X, m.p. 217–218° (s.216°), 2.84 g. of potassium hydroxide pellets (85%) and 40 ml. of methanol was refluxed with good stirring for 1.5 hours. Then 4.7 g. (0.04 mole) of methyl chloroacetate in 10 ml. of methanol was added with stirring during a few minutes. Two hours later the mixture was cooled, poured into 100 ml. of water, and the precipitate filtered. The dry, crude product weighed 5.83 g. (67%), m.p. 150–230°. Recrystallization from dioxane–water, then from ethyl acetate with hot filtration gave XII, m.p. 130–133° (s.125°).

*Anal.* Calcd. for  $C_{22}H_{22}O_4S_2$ : C, 63.74; H, 5.35; S, 15.47. Found: C, 63.23; H, 5.04; S, 15.32.

**9,10-Anthracene-bis-5'-(4'-thiapentanenitrile) (XIII).**—A mixture of 4.0 g. (0.015 mole) of X and 20.0 g. of freshly distilled acrylonitrile was warmed to recipient reflux without noticeable change. After cooling nearly to room temperature four drops of Triton-B was added, and an exothermic reaction ensued. The mixture was stirred just below the reflux temperature for 1.5 hours after the exotherm had abated. After cooling the yellow suspension was removed by filtration. The dry weight of crude material was 5.04 g. (89%), m.p. 192–195°. Two recrystallizations from dioxane, followed by pumping overnight at 60° (0.8 mm.) gave yellow needles of XIII, m.p. 200–201° (s.199°).

*Anal.* Calcd. for  $C_{22}H_{20}N_2S_2$ : C, 70.18; H, 5.35; N, 7.44; S, 17.03. Found: C, 69.88; H, 5.08; N, 7.21; S, 17.15.

**9,10-Anthracenediacetonitrile (XIV).**—A mixture of 800 ml. of methyl isobutyl ketone, 400 ml. of purified dioxane, 200 ml. of water, 150 g. (2.22 moles) of 97% potassium cyanide and 1 g. of cuprous cyanide was heated to reflux with rapid stirring to cause intimate mixture of the two layers. Then over a period of two hours was added 50.0 g. (0.182 mole) of I, m.p. 255–260°. Late in the addition period an orange solid began to separate. After addition was complete, heating and stirring were continued for seven hours, and the reaction mixture allowed to stand overnight. The solid was removed by filtration, and the filtrate concentrated to yield a slight additional quantity. The total solid material was recrystallized from the minimum quantity of dimethylformamide to give 21.2 g. (45%) of crude XIV, m.p. 320–325°. A sample purified for analysis by two sublimations at 190–200° (0.1 mm.) consisted of bright yellow needles and blades, m.p. 335–338° dec.

*Anal.* Calcd. for  $C_{18}H_{12}N_2$ : C, 84.25; H, 4.72; N, 10.93. Found: C, 84.52; H, 4.96; N, 10.37.

**9,10-Anthracenediacetic Acid (XVI).**—A mixture of 7.0 g. (0.027 mole) of XIV, 18.0 g. (0.27 mole) of potassium hydroxide (pellets, 85%) and 200 ml. of *sec*-butyl alcohol was stirred at reflux for 66 hours. Most of the alcohol was removed under reduced pressure, and the residue dissolved in the minimum of water. The aqueous solution was cooled and acidified with concentrated hydrochloric acid. The resulting mixture was extracted thoroughly with chloroform. The chloroform solution was in turn extracted with 10% sodium carbonate solution. Acidification of the cooled basic extract gave 7.5 g. (92%) crude, yellow, amorphous diacid, m.p. 270–300° (s.210°). Two recrystallizations

(13) When peroxide-containing dioxane was used, partial oxidation gave insoluble material, probably disulfides.

from dioxane–water gave 6.1 g. of fine, bright, buff-yellow, fusiform blades. An analytical sample of XVI was desiccated at 60° (0.6 mm.) for 20 hours, m.p. 310–315° dec. (s.300°).

*Anal.* Calcd. for  $C_{18}H_{14}O_4$ : C, 73.46; H, 4.79. Found: C, 72.98; H, 4.91.

**Methyl 9,10-Anthracenediacetate (XVII) and 9,10-Anthracenediacetamide (XV).**—Each of two Carius tubes was charged with 2.0 g. (total 0.016 mole) of XIV, 60 ml. of purified dioxane, which had been previously saturated with hydrogen chloride, and 30 ml. of anhydrous methanol. The tubes were frozen, sealed, and stored at room temperature with occasional agitation for 3.5 days. The tubes were frozen, opened, and the contents poured into 800 ml. of water. The yellow precipitate was removed by filtration, and the filtrate concentrated to yield more of the yellow solid. The combined solid was extracted with 400 ml. of warm methanol, which dissolved the bright yellow material, leaving a buff-colored powder.

Concentration of the filtrate gave 1.01 g. (20%) of XVII as yellow needles, m.p. 189–191°. After another recrystallization from acetonitrile followed by desiccation in an Abderhalden pistol over paraffin chips at 60° (0.5 mm.) overnight, the m.p. was 190–192° (subl. from 155°, opacity from 165°, some previous softening).

*Anal.* Calcd. for  $C_{20}H_{18}O_4$ : C, 74.52; H, 5.63. Found: C, 74.54; H, 5.51.

The residue from the methanol extraction weighed 3.44 g. (76% calculated as XV), m.p. < 350°, and was insoluble in common solvents, but recrystallizable from large volumes of dimethylformamide. A 1-g. sample was recrystallized from about one liter of dimethylformamide and dried at 100° (0.4 mm.) over phosphorus pentoxide for 60 hours to give pale, bright yellow prisms of XV, m.p. 380–385° (dec.) (subl. and darkening from 370°).

*Anal.* Calcd. for  $C_{18}H_{16}N_2O_2$ : C, 73.94; H, 5.53; N, 9.58. Found: C, 73.59; H, 5.87; N, 9.88.

**9,10-Anthracene-bis-(2'-ethanol) (XVIII).**—To 1.0 g. of lithium aluminum hydride dissolved in 40 ml. of dry tetrahydrofuran was added during one-half hour 0.55 g. (0.002 mole) of XVII dissolved in 60 ml. of dry tetrahydrofuran. The deep violet solution was stirred for another hour near reflux temperature. After cooling, water was added cautiously, then the mixture was acidified with hydrochloric acid. The layers were separated and the aqueous phase extracted thoroughly with ethyl acetate and chloroform. Evaporation of the combined, dry organic solutions gave a yellow powder, which, after one recrystallization from ethanol–water, weighed 0.34 g. (76%), m.p. 197–204°. Two more recrystallizations from the same solvents, and drying 20 hours over potassium hydroxide pellets at 60° (1 mm.) gave XVIII as yellow needles, m.p. 215–217° (s.207°).

*Anal.* Calcd. for  $C_{18}H_{18}O_2$ : C, 81.17; H, 6.81. Found: C, 81.24; H, 6.78.

**Methyl 9,10-Anthracenedipropionate (XX).**—The synthesis of XIX was accomplished essentially by the procedure of Postovskii and Bednyagina,<sup>3</sup> which involved treatment of I with sodiomalonic ester.<sup>14</sup> A significant improvement in yield was effected by thermal decarboxylation of the intermediate tetra-acid in diphenyl ether solution, rather than simple pyrolysis of the powdery intermediate at reduced pressure.

Forty-five grams (0.140 mole) of XIX, m.p. 251–253°, was refluxed overnight with 400 ml. of methanol, 400 ml. of benzene and a few drops of concentrated hydrochloric acid. The solvents were concentrated and cooled to give 47.4 g. (97%) of crystalline XX, m.p. 142–145°. Two recrystallizations from methanol followed by one sublimation at 170° (1 mm.) gave straw-colored needles of XX, m.p. 145.8–147°.

*Anal.* Calcd. for  $C_{22}H_{22}O_4$ : C, 75.41; H, 6.33. Found: C, 75.65; H, 6.31.

**9,10-Anthracene-bis-(3'-propionamide) (XXI).**—Two grams (0.006 mole) of XIX, m.p. 142–145°, was dissolved in a mixture of 70 ml. of purified dioxane and 20 ml. of anhydrous methanol. This solution was charged into a Carius tube, frozen in a Dry Ice–acetone mixture, and about 20 ml. of anhydrous ammonia added. The tube was sealed,

(14) We are grateful to Dr. Jeanne C. Johnson for samples of 9,10-anthracenedipropionic acid and the methyl ester.

and the homogeneous yellow solution (violet fluorescence) allowed to stand at ambient temperatures for two days. The tube was then frozen, opened, and the ammonia and solvents evaporated. Recrystallization of the residual yellow powder from methanol gave 1.41 g. (77%) of crude diamide, m.p. 300–302°. An analytical sample was prepared by a second recrystallization from methanol and desiccation overnight at 60° (0.4 mm.) to give XXI as fine yellow needles, m.p. 310–315° dec.

*Anal.* Calcd. for  $C_{20}H_{20}O_2N_2$ : C, 74.97; H, 6.29; N, 8.75. Found: C, 74.69; H, 6.95; N, 8.31.

**9,10-Anthracene-bis-(3'-propanol) (XXII).**—A solution of 1.0 g. of lithium aluminum hydride (70%) in dry tetrahydrofuran was stirred while a solution of 1.0 g. (0.003 mole) of XIX, m.p. 142–145°, in 50 ml. of dry tetrahydrofuran was added dropwise. The mixture was stirred at reflux for three hours after addition was complete. After cooling, water was added cautiously, then enough dilute hydrochloric acid to acidify. A small quantity of insoluble mate-

rial was removed by filtration, and the layers separated. The aqueous layer was extracted twice with ethyl acetate, and the combined organic solutions (deep indigo fluorescence) dried over anhydrous sodium sulfate. Concentration to 20-ml. volume and cooling gave 0.85 g. (100%) of pale tan crystals, m.p. 174–176°. Recrystallization from 95% ethanol with charcoal treatment followed by one sublimation at 200–210° (0.9 mm.) gave straw-colored crystals of XXII, m.p. 173.5–175°.

*Anal.* Calcd. for  $C_{20}H_{22}O_2$ : C, 81.59; H, 7.54. Found: C, 81.76; H, 7.19.

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PASSAIC, NEW JERSEY

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

## Piperidine Derivatives. XXVII. The Condensation of 4-Piperidones and Piperidinols with Phenols

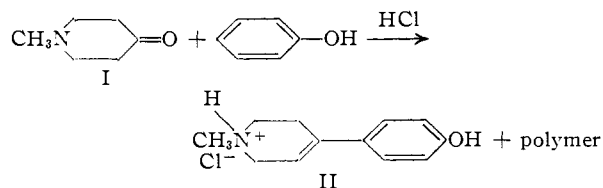
BY S. M. McELVAIN AND RICHARD S. BERGER<sup>1</sup>

RECEIVED JANUARY 13, 1955

1-Methyl-4-piperidone is condensed by hydrogen chloride with phenol and 2,4-dimethylphenol to yield a 4-aryl-tetrahydropyridine (II and IV), but with 2,6-dimethylphenol the diphenol IIIa is formed. Considerable amphoteric polymeric material is formed with the piperidone and phenol; similar polymers are the only reaction products where resorcinol or its monomethyl ether is used instead of phenol. 3-Substituted 4-piperidones do not condense with phenol. 1-Methyl-4-phenyl-4-hydroxypiperidine condenses with phenols in 60% sulfuric acid to yield 4,4-diarylpiperidines (VI and VIIa), but the corresponding 4-alkyl-4-hydroxypiperidines are only dehydrated under these conditions.

The condensation of phenols with 4-piperidones and piperidinols, extensions of reactions that have been successfully carried out with simple ketones<sup>2</sup> and tertiary alcohols,<sup>3</sup> seemed to offer an attractive preparative route to certain 4,4-disubstituted piperidines. The results of a study of these reactions are now reported.

1-Methyl-4-piperidone (I) condensed with phenol in an acetic acid solution of hydrogen chloride to yield the tetrahydropyridine II (50%) and an amphoteric polymer. This latter material resists purification by crystallization and gradually darkens on standing. Inasmuch as the crystalline condensation product (II) is unchanged on further treatment with the acetic acid–hydrogen chloride solution, it is not the precursor of the polymer.



The *p*-orientation of II was shown by its conversion by hydrogenation to 1-methyl-4-(*p*-hydroxyphenyl)-piperidine, the hydrobromide of which has been described.<sup>4</sup>

(1) Monsanto Chemical Company Fellow, 1932–1953; Sinclair Oil Company Fellow, 1953–1954.

(2) J. B. Niederl, *et al.*, *THIS JOURNAL*, **61**, 345 (1939); **62**, 320 (1940).

(3) (a) R. C. Huston and G. W. Herrick, *ibid.*, **59**, 2001 (1937);

(b) Ng. Ph. Buu Hoi, *J. Org. Chem.*, **18**, 4 (1953).

(4) A. Ziering, *et al.*, *ibid.*, **12**, 894 (1947).

The tetrahydropyridine (II) could not be made to add acetic acid, water or acetonitrile<sup>5</sup> across the double bond in the presence of a variety of acidic catalysts. However, it did add phenol in a 60% sulfuric acid solution to yield the diphenol III. It appears from these results that such groups as  $-OCHOCH_3$ ,  $-OH$  and  $-NHCOCH_3$  are as easily removed from, as they are attached to, the 4-position of protonated II, and that the establishment of a carbon to carbon bond is necessary to produce a stable 4,4-disubstituted piperidine under these acidic conditions.

In contrast to I, 3-ethyl(or benzyl)-4-piperidone<sup>6</sup> failed to condense with phenol under a variety of acidic conditions; in each case the piperidone was recovered unchanged. When resorcinol and its monomethyl ether were substituted for phenol in the reaction with I only the amphoteric polymeric material was obtained. These latter results and the failure of II to be converted into the polymer suggest that the intermediate carbinol, 1-methyl-4-(*p*-hydroxyphenyl)-4-hydroxypiperidine, or the carbonium ion derived from it, undergoes self-condensation to give the polymer before it decomposes into the stable tetrahydropyridine (II).

Such a conclusion concerning the origin of the polymeric material indicated that a phenol with a single reactive ring position would not produce any of the polymer. Indeed, it was found that the condensation of 2,6-dimethylphenol with I in an acetic acid solution of hydrogen chloride gave the diphenol IIIa in 86% yield, while the condensation with 2,4-

(5) Cf. H. Plant and J. J. Ritter, *ibid.*, **73**, 4076 (1951).

(6) G. Stork and S. M. McElvain, *ibid.*, **68**, 1053 (1946).