In a previous paper[8] it was suggested that the formation of these amino acids may be due to an increased ability of the *o*-nitroso group to add an aldehyde complex and then rearrange. This does not seem to be true of the *p*-nitroso derivatives (XXIIIa, XXIVa, XXVa), since they exhibit strong oxidizing properties, yielding amines and azoxy compounds.

Halogen Removal.—While varying amounts of halogen were removed in many cases, no definite phenols were isolated. This is probably due to the interaction of the intermediate nitroso compounds with such phenols, yielding tarry products.

Summary

1. A study has been made of the action of sodium alcoholates (or tautomeric substances) on nitrobenzene, substituted nitrobenzenes and nitrosobenzenes in anhydrous benzene solution.

2. The products are normally amines or the corresponding azoxy derivatives, though polyhydric alcohols tend to form azo compounds.

3. Sodium derivatives of tautomeric substances are often good reducing agents, being oxidized usually at the methylene bond.

4. When *p*-nitrotoluene or its substitution products are used, stilbenes may be formed.

5. No substituting groups other than halogen form α-amino acids.

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[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF THE UNIVERSITY OF ILLINOIS]

STEREOCHEMISTRY OF DIPHENYLS. PREPARATION AND PROPERTIES OF 4,4′-DICARBOXY-1,1′-DIANTHRAQUINOYL. XVII[1]

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It was pointed out in a previous paper[2] that it should be possible to resolve a 2,2′-disubstituted diphenyl derivative into optical antipodes, provided the two substituting groups are sufficiently large and assuming that a hydrogen atom may serve as a blocking group. Diphenyl-2,2′-disulfonic acid[3] was investigated but it could not be resolved. In the present investigation 4,4′-dicarboxy-1,1′-dianthraquinoyl (I) and its di-*l*-menthyl ester were synthesized in order to determine whether the CO group in a quinone ring would be a sufficiently large 2-substituted group to cause inter-

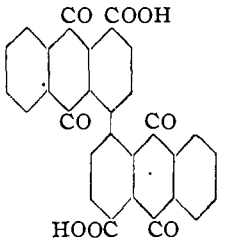
[8] Ref. 2, p. 2738.

[1] For the two previous papers in this series see Shildneck and Adams, THIS JOURNAL, **53**, 2203 (1931); Chang and Adams, *ibid.*, **53**, 2353 (1931).

[2] Stanley and Adams, *ibid.*, **52**, 1200 (1930).

[3] Stanley and Adams, *ibid.*, **52**, 4471 (1930).

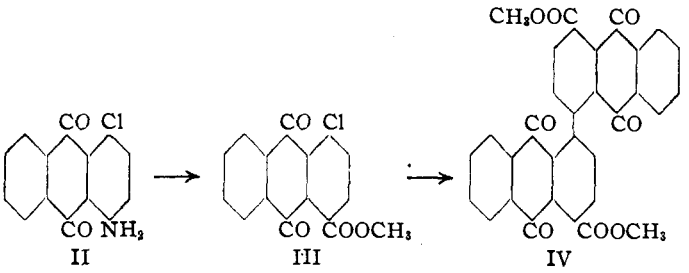
ference with the 2′-hydrogen atom and thus allow resolution into optical isomers. It could not, however, be resolved.



I

If the interference of the C—CO is calculated as an additive value of the C—C and C=O distances (2.45 Å.), an assumption which is hardly warranted, the compound should be resolvable: C—CO, 2.45 Å. + C—H, 0.94 Å. ⟶ 3.39 Å. − 2.90 Å. (distance between 2,2′ carbons) ⟶ 0.49 Å. On such a basis, the x-ray values do not agree with the facts. However, there are factors in the structure of such a compound as has been described in this investigation which make it somewhat different from the simple diphenyls. The positions of the carbon atoms in the quinone rings are fixed in such a way that the effective interference diameter of each of the C—C and of the C=O groups would probably be modified from that in an ordinary diphenyl. Certainly the values would not be additive. The forces of the C=O group extend probably in a vertical direction from the quinone ring and, therefore, with the fixed position of the carbon atom, a set of conditions is introduced which necessitates a modification of the simple assumption for interfering values which has been used so successfully for the diphenyls with no condensed nuclei.

The 4,4′-dicarboxy-1,1′-dianthraquinoyl was prepared from 1-chloro-4-benzoylaminoanthraquinone by removal of the benzoyl group, diazotization and replacement of the amino group by a cyano group, hydrolysis and esterification of this derivative to give 1-chloro-4-carbomethoxyanthraquinone, condensation of this to 4,4′-dicarbomethoxy-1,1′-dianthraquinoyl and saponification of this to the acid. Due to its extreme insolubility the dimethyl ester was not isolated from the condensation reaction mixture, the uncoupled 1-chloro-4-carbomethoxyanthraquinone being removed by extraction with chloroform and the residual mixture being saponified directly to give 4,4′-dicarboxy-1,1′-dianthraquinoyl. It was impossible to purify the free acid by crystallization due to its slight solubility. Purification was accomplished by crystallization of the disodium salt, repeated treatment with charcoal in alkaline solution, and repeated precipitation of the acid from solutions of the salt by means of dilute mineral acid.



It was found impossible to fractionate the alkaloid salts of 4,4′-dicarboxy-1,1′-dianthraquinoyl due to their insolubility. In one experiment the monoquinine salt of the acid was extracted with three liters of hot *p*-cymene with no indication of resolution. It was also found impossible to render the acid soluble by forming the monoquinine-monosodium salt of the acid since this derivative rearranged to a mixture consisting mainly of the disodium salt and the diquinine salt. The di-*l*-menthyl ester was prepared and fractionated from three different solvents without giving any change in the rotation or melting point.

The authors wish to thank The Jackson Laboratory of E. I. du Pont de Nemours and Co. through Mr. Clark for the 1-chloro-4-benzoylaminoanthraquinone used in this investigation.

Experimental Part

1-Chloro-4-aminoanthraquinone (II).—A solution of 250 g. of technical 1-chloro-4-benzoylaminoanthraquinone in 400 cc. of concentrated sulfuric acid was heated to 80–90° for four hours. The solution was then cooled to 0° and poured slowly onto ice with continual stirring. The red precipitate was removed by filtration, warmed with strong ammonium hydroxide, filtered and washed with dilute ammonium hydroxide until the filtrate gave no precipitate upon acidification. After a final washing with 250 cc. of water, the red precipitate was dried under vacuum at 100°. The yield was 175 g.

1-Chloro-4-cyanoanthraquinone.—A solution of 55 g. of sodium nitrite in 500 cc. of concentrated sulfuric acid was prepared by dusting small portions of thoroughly dried sodium nitrite powder into concentrated sulfuric acid at 0° with continual stirring. The addition required about forty minutes, after which the sulfuric acid was heated to 50–60° to effect complete solution of the sodium nitrite. The solution was then cooled to 0°, and to it was added an ice-cold solution of 175 g. of 1-chloro-4-aminoanthraquinone in 850 cc. of concentrated sulfuric acid. After standing at 0° for fourteen hours, the solution was poured slowly with stirring onto cracked ice. The bright yellow precipitate which formed was quickly removed by filtration with suction, washed with 100 cc. of ice water and immediately taken up in 3 liters of ice water. This mixture was added slowly to a cold solution of 325 g. of cupric sulfate pentahydrate and 365 g. of potassium cyanide in 2 liters of water. This solution was previously prepared by adding a saturated aqueous solution of potassium cyanide to a boiling aqueous solution of cupric sulfate. After the addition of the diazonium salt, the mixture was heated to boiling during three hours and filtered hot. The precipitate was washed with hot 10% aqueous potassium cyanide solution and finally with 8 liters of boiling water. After drying, the precipitate weighed 250 g., so it was heated to boiling with 2 liters of 5% aqueous potas-

sium cyanide, filtered hot, washed with 2 liters of hot 5% aqueous potassium cyanide, then with 4 liters of boiling water and dried. The yield was 155 g. (85%) of a product melting at 265–268°. The melting point after two crystallizations from glacial acetic acid was 271–272°.

Anal. Calcd. for $C_{15}H_6O_2NCl$: Cl, 13.25. Found: Cl, 12.97.

1-Chloro-4-carboxyanthraquinone.—A mixture of 150 g. of 1-chloro-4-cyanoanthraquinone, 300 cc. of water and 900 cc. of concentrated sulfuric acid was heated to boiling (190°), cooled and diluted with 2 liters of water. The precipitate so obtained was removed by filtration, washed with water and then digested and washed with a total of five liters of dilute ammonium hydroxide. The ammoniacal filtrate was acidified and the brown colored acid so obtained was removed and dried. The yield was 135 g. (82%) of a product melting at 220–224° without recrystallization. Heller and Schulke[4] give the melting point of 1-chloro-4-carboxy anthraquinone obtained by the oxidation of 1-chloro-4-methylanthraquinone as 228–229° after two crystallizations.

1-Chloro-4-carbomethoxyanthraquinone (III).—A mixture of 66 g. of 1-chloro-4-carboxyanthraquinone and 2 liters of absolute methyl alcohol was saturated with dry hydrogen chloride (required 580 g.). After refluxing for twenty-four hours, 600 cc. of alcohol was removed by distillation, and the residual mixture was cooled to 0° and filtered. The precipitate was washed with water, then with dilute sodium carbonate solution until acidification of the filtrate gave no precipitate and finally with water. The yield was 60 g. (87.5%) of a product melting at 183–185°. The run was repeated using 34 g. of 1-chloro-4-carboxyanthraquinone and 500 g. of absolute methyl alcohol. The yield was 30 g. (85%). The ester was recrystallized twice from chloroform and gave large rhombic crystals having a melting point of 187.5–188.5°.

Anal. Calcd. for $C_{16}H_9O_4Cl$: Cl, 11.80. Found: Cl, 11.90.

4,4'-Dicarboxy-1,1'-dianthraquinoyl (I).—A mixture of 30 g. of 1-chloro-4-carbomethoxyanthraquinone and 30 g. of copper powder (Kahlbaum's Naturkupfer C) in a Pyrex tube was heated by means of a metal bath slowly to 265° during ten minutes and then at 265° for twenty minutes with occasional stirring. A noticeable reaction took place at about 250° during which the temperature of the mixture went to 300°. The run was repeated using 54 g. of 1-chloro-4-carbomethoxyanthraquinone and 75 g. of copper powder. The two runs were combined, cooled, pulverized and extracted with 500 cc. of hot chloroform, the evaporation of which gave 30 g. of solid material. The reaction mixture was again extracted successively with 300 cc. and with 200 cc. of chloroform, the evaporation of which gave 2.0 g. and 0.5 g., respectively, of solid material, thus indicating the removal of the uncoupled material. The remaining mixture, consisting of copper powder, copper chloride, and 4,4'-dicarbomethoxy-1,1'-dianthraquinoyl, was refluxed with a mixture of 32 g. of potassium hydroxide and 800 cc. of ethyl alcohol for twelve hours. The alcohol was removed by distillation, the residue was heated to boiling with 750 cc. of water and filtered hot. The residue was extracted twice with 500 cc. of hot water, and the combined filtrates acidified with hydrochloric acid. The light brown precipitate of 4,4'-dicarboxy-1,1'-dianthraquinoyl was removed by filtration and dried. The yield was 44 g. of a product melting unsharply from 350–360°. The disodium salt of the acid was crystallized from water and then dissolved in water, boiled with charcoal, filtered and precipitated with hydrochloric acid six successive times. The light cream colored acid so obtained weighed 25 g. and melted sharply at 448° (corr.) on the block. The acid is slightly soluble in pyridine (0.06 g. in 100 g.) and insoluble in all other common solvents.

Anal. Calcd. for $C_{30}H_{14}O_8$: C, 71.69; H, 2.81. Found: C, 71.31; H, 2.81.

[4] Heller and Schulke, *Ber.*, **41**, 3636 (1908).

Di-*l*-menthyl Ester of 4,4'-Dicarboxy-1,1'-dianthraquinoyl.—A mixture of 5 g. of 4,4'-dicarboxy-1,1'-dianthraquinoyl and 175 g. of thionyl chloride was refluxed for six hours, the acid going slowly into solution. The excess thionyl chloride was carefully removed under vacuum and the yellow residue dried until the odor of thionyl chloride was very faint. A 10-g. portion of *l*-menthol was then added and the mixture heated to 150° for six hours, after which 150 cc. of dry benzene was added and the mixture refluxed for six hours. The benzene was removed under vacuum, and the residue steam distilled to remove the excess *l*-menthol. The residue was recrystallized from chloroform, giving 6.5 g. (85%) of light yellow product melting at 298–299°. The di-*l*-menthyl ester is soluble in chloroform, slightly soluble in ether, ethyl acetate and acetone and insoluble in petroleum ether and ethyl alcohol.

Rotation. 0.2206 g. made up to 12 cc. with chloroform at 20° gave α_D 0.28; $l = 1$; $[\alpha]_D^{20}$ −15.2°.

Anal. Subs., 3.974 mg.; CO_2, 11.19 mg.; H_2O, 2.27 mg. Calcd. for $C_{50}H_{50}O_8$: C, 77.08; H, 6.47. Found: C, 76.79; H, 6.39.

Fractionation of the ester from chloroform, ether and ethyl acetate did not change the rotation or the melting point.

Attempt to Resolve 4,4'-Dicarboxy-1,1'-dianthraquinoyl with Quinine.—A mixture of 5.02 g. (0.01 mole) of 4,4'-dicarboxy-1,1'-dianthraquinoyl, 3.24 g. (0.01 mole) of quinine and 200 cc. of chloroform was refluxed for sixty hours. The mixture was then cooled and the insoluble material was removed by filtration. This material consisted of the quinine salt, since the weight was 8.26 g. It had an unsharp melting point starting at 210°. The salt is insoluble in benzene, *p*-cymene, acetone, gasoline, chloroform, alcohol, nitrobenzene, ethyl acetate and ether. The extraction of 3 g. of salt with 2 liters of hot *p*-cymene gave about 0.1 g. of salt, the acid from which gave no rotation in 0.1 *N* sodium hydroxide. Pyridine was found to decompose the salt. An attempt was then made to solubilize the salt by forming the mono-quinine mono-sodium salt. To a suspension of 4 g. of the mono-quinine salt of 4,4'-dicarboxyl-1,1'-dianthraquinoyl in 400 cc. of water was added slowly 47 cc. of 0.108 *N* sodium hydroxide solution (1 equiv.). The mixture was warmed for six hours at 80° and filtered from 2.6 g. of insoluble material. The insoluble material was again combined with the filtrate and warmed for twelve hours at 80°. The amount of insoluble material was again 2.6 g. The material was found to be the diquinine salt, for upon hydrolysis one equivalent of acid and two equivalents of quinine were obtained. The soluble portion was found to consist chiefly of the disodium salt. It gave no rotation in aqueous or pyridine solution.

Summary

1. 4,4'-Dicarboxy-1,1'-dianthraquinoyl and its di-*l*-menthyl ester have been prepared. Only one di-*l*-menthyl ester was obtained.

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