The residue left after treating with boiling alcohol was tested with ammoniacal silver nitrate solution but it did not precipitate silver and was not precipitated by calcium hydroxide in the cold, though it was precipitated on heating.

The free acid was crystallized later and the rhombic prisms of citric acid identified.

SUMMARY.

Adlumia cirrhosa contains at least five distinct alkaloids as follows:

(1) Protopine, $C_{20}H_{19}NO_5$, melting-point 204°-205° C.

(2) β-Homochelidonine, $C_{21}H_{23}NO_5$, melting-point 159° C.

(3) Adlumine, $C_{39}H_{39}NO_{12}$ or $C_{39}H_{41}NO_{12}$, melting-point 187°-188° C.

(4) Adlumidine, $C_{30}H_{29}NO_9$, melting-point 234° C.

(5) Unnamed, melting-point 176°-177° C.

Also tartaric and citric acids.

The investigation is being continued.

SCHOOL OF PHARMACY, UNIVERSITY OF MICHIGAN,
ANN ARBOR, MICH.

[CONTRIBUTIONS FROM THE HAVEMEYER LABORATORIES, COLUMBIA UNIVERSITY, NO. 78].

3-NITROPHTHALYL CHLORIDE AND ITS ACTION WITH AMMONIA AND WITH AROMATIC AMINES.

BY VICTOR JOHN CHAMBERS.

Received April 6, 1903.

THE action of phosphorus pentachloride upon 3-nitrophthalic acid has been tried before, but the product isolated from the reaction mass has not been the acid chloride. Boroschek[1] obtained the anhydride of 3-nitrophthalic acid and also the anhydride of 3-chlorphthalic acid. Levi[2] obtained only the anhydride of 3-nitrophthalic acid.

By using the process described in the experimental part, the author was able to obtain the acid chloride in the form of colorless, transparent, well-defined crystals melting at 76°-77° corr.

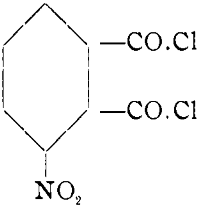
Phthalyl chloride, as is well known, has been assigned both a

---

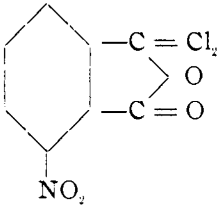
[1] Inaug. Dissertation, 1901.

[2] Inaug. Dissertation, 1891.

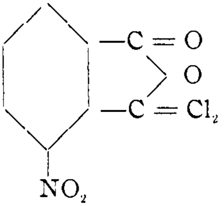
symmetrical and an unsymmetrical structure. The presence of the nitro group in 3-nitrophthalyl chloride introduces another possibility. If the chloride be symmetrical it can have only the one structure, A, but if a asymmetrical it can have either of the two forms B and C.



A.



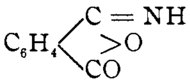
B.



C.

The study of its action with various reagents, such as ammonia, substituted ammonias, alcohols and phenols, was undertaken in the hope of throwing some light upon this question. The action with ammonia and various substituted ammonias is reported in the present paper. The study of the action of alcohols and phenols is being carried on at the present time.

The action of ammonia upon phthalyl chloride has been tried under various conditions. Kuhara[1] passed dry ammonia gas over dry phthalyl chloride and obtained phthalimide as the result of a violent reaction. He also treated the chloride with aqueous ammonia and then the resulting solution with hydrochloric acid. On washing and crystallizing the product from alcohol, beautiful crystals were obtained that gave the same analytical results as phthalimide and yet showed different properties. He proposed the unsymmetrical structure



$$C_6H_4\left\langle\begin{matrix}C = NH\\ \quad >O\\ CO\end{matrix}\right.$$

for the substance.

Auger[2] obtained a product he called the unsymmetrical amide of phthalic acid by treating the chloride with an excess of concentrated ammonia and evaporating over sulphuric acid. This amide, when treated with hydrochloric acid, gave a body isomeric with phthalimide.

Hoogewerff and Van Dorp[3] treated phthalyl chloride with a

---

[1] *Am. Chem. J.* **3**, 26.

[2] *Ann. chim. phys.*, (6), **22**, 289.

[3] *Rec. trav. chim. Pays-Bas*, **11**, 84.

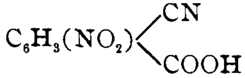
cold aqueous solution of ammonia, care being taken to prevent rise of temperature. After an excss had been added, the solution was acidified with hydrochloric acid. A crystalline substance separated that had the following properties: It melted at 180°-190°, solidifying again as the temperature rose and remelting at that of the imide; it had acid properties, forming a number of salts; it was easily decomposed by boiling with water and was changed to phthalamic acid by the action of concentrated sulphuric acid; it formed esters, and the ethyl ester was identical with that prepared by Miller from the *o*-cyanbenzoic acid made from anthranilic acid by the Sandmeyer reaction. The preparation of this acid from phthalyl chloride indicates the unsymmetrical structure for that chloride.

The action of dry ammonia upon dry 3-nitrophthalyl chloride was analogous to that upon the unsubstituted chloride. The imide was obtained.

The action of aqueous ammonia was different, however. No cyan acid could be obtained, the original 3-nitrophthalic acid being the only product. The reason for this was clear when it was found that the cyan acid, which was obtained by another method, was unstable in the presence of the slightest amount of water, passing to an acid ammonium salt of 3-nitrophthalic acid. This in turn gave the original nitrophthalic acid when acidulated. The action of aqueous ammonia upon a chloroform solution of the chloride, with cooling, was found to give a 3-nitrophthalamic acid.

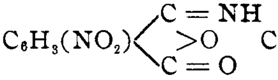
The action of dry gaseous ammonia upon a dry ethereal solution of the chloride at a low temperature and subsequent treatment with hydrochloric acid gas gave a substance that had the same composition as 3-nitrophthalimide. This new substance melted at 99°-100° and then rearranged to the imide as the temperature was raised to 105°.

There are three possible structures that may be assigned to this body, leaving out of question for the moment the relation of the nitro group to the other groups. They are



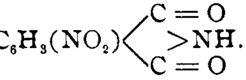
$$C_6H_3(NO_2)\begin{cases} CN \\ COOH \end{cases}$$

I.



$$C_6H_3(NO_2)\begin{cases} C = NH \\ \quad >O \\ C = O \end{cases}$$

II.

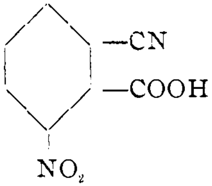


$$C_6H_3(NO_2)\begin{cases} C = O \\ \quad >NH. \\ C = O \end{cases}$$

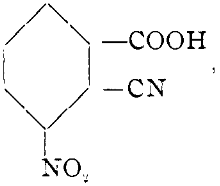
III.

III is usually assigned to the well-known imide. Moreover, if ammonia gave, under the conditions described, a product to be represented by either II or III it would be reasonable to expect that primary amines would give analogous bodies under like conditions. No such bodies could be obtained. It seems probable, therefore, that the substance in question is a nitrocyanbenzoic acid. One reason that Hoogewerff and Van Dorp gave for the cyan structure of the body they obtained by the action of ammonia upon phthalyl chloride was that the same body was formed by the introduction of CN in place of NH_2 in anthranilic acid. This proof could not be applied in this case as the compound is unstable in the presence of water. In that respect it differs from *o*-cyanbenzoic acid. For the same reason it could not be changed to the corresponding amic acid by treatment with concentrated sulphuric acid and then with water.

There are, however, two possible formulas that may be assigned to a cyan acid derived from 3-nitrophthalyl chloride:

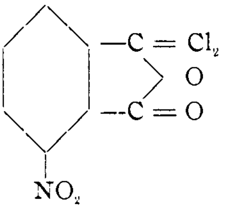


I.

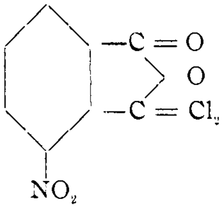


II.

These would be derived from the two theoretically possible chlorides:



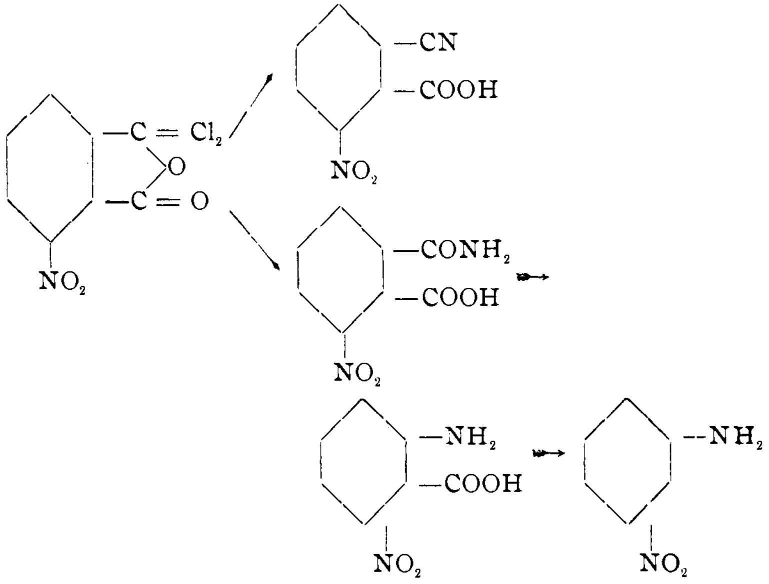
A.



B.

It was found that the cyan acid obtained is to be given formula I and that, in consequence, formula A is the correct one for 3-nitrophthalyl chloride, if that body is to be assigned an asymmetrical structure.

While 3-nitrophthalyl chloride gave a nitrocyanbenzoic acid under certain conditions, it gave a nitrophthalamic acid under others. It is fair to assume that the CN group in one case and the $CONH_2$ group in the other are in the same position in the molecule. The structure of this amic acid was obtained by the same method used by Kahn[1] to prove the structure of an acid methyl ester of 3-nitrophthalic acid. The nitrophthalamic acid was changed to a nitroanthranilic acid and its melting-point was that of the 2-nitro-6-aminobenzoic acid obtained by Kahn. Carbon dioxide was then eliminated from this acid and *m*-nitraniline obtained.



Van der Meulen[2] obtained phthalanilide by the action of aniline upon the hydrochloride of isophthalanil.

Rogow[3] shortly afterwards obtained it by the action of aniline upon phthalyl chloride.

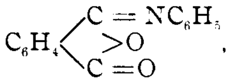
Kuhara and Fukui[4] tried the action of a cold ethereal solution of aniline upon a similar solution of phthalyl chloride. A white solid was obtained which was washed with hydrochloric acid, ammonia, and water, and then extracted several times with small portions of boiling alcohol. It was crystallized from glacial acetic acid, and then from a large amount of boiling alcohol. A quantity of fine white needles was obtained. Analysis for nitrogen

---

[1] *Ber. d. chem. Ges.*, **35**, 631.
[2] *Rec. trav. chim. Pays-Bas*, **15**, 323.
[3] *Ber. d. chem. Ges.*, **30**, 1442.
[4] *Am. Chem. J.*, **26**, 454.

indicated a composition similar to that of the phthalanil. It differed markedly, however, from the known phthalanil.

Kuhara and Fukui gave it the structure



$$C_6H_4\left\langle\begin{array}{l}C=NC_6H_5\\ \quad >O\\ C=O\end{array}\right. ,$$

asymmetrical phthalanil. A similar compound was obtained from phthalyl chloride and orthotoluidine.

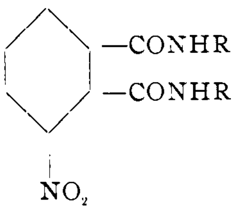
If a compound of this nature could be obtained when aniline is used instead of ammonia, it would point strongly to a similar structure for the so-called cyan acid.

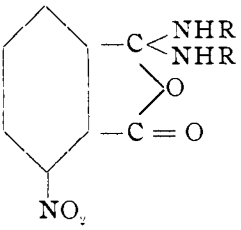
The experiments of Kuhara and Fukui were tried with 3-nitrophthalyl chloride. A similar-looking product was obtained but analysis showed it to correspond to a 3-nitrophthalanilide. The experiment was tried a number of times with the same results. Paratoluidine, metanitroaniline and paranitraniline were substituted for aniline and similar products were obtained.

When the work was at this stage an article appeared by Hoogewerff and Van Dorp.[1] Their work indicated that Kuhara and Fukui really had phthalanilide which was transformed to phthalanil by the crystallization from glacial acetic acid.

That corresponded with the results obtained with 3-nitrophthalyl chloride and it only remained to show that the anilides obtained were also transformed to the anils by action of hot glacial acetic acid. This was found to be true in every case.

The action of a primary aromatic amine upon 3-nitrophthalyl chloride is then to introduce two molecules of the amine. The resulting compounds may have either of the two following structures:





No experimental proof was obtained that would indicate which of the two is the correct one.

---

[1] *Rec. trav. chim. Pays-Bas*, **21**, 339.

EXPERIMENTAL PART.

The chloride was made by the action of phosphorus pentachloride upon 3-nitrophthalic acid.

This acid was prepared by the Miller method as modified by Bogert and Boroschek.[1] 150 grams of phthalic anhydride were treated with a mixture of 225 grams of concentrated sulphuric acid and 225 grams of fuming nitric acid. The whole was heated in a roomy casserole on a water-bath until the nitrophthalic acids began to separate from the solution. About 20 cc. of water were then added and the whole heated a couple of hours longer. The mixture was then allowed to stand over night. The crystals were separated as completely as possible from the acid mother-liquor and dissolved in about 750 cc. of water. This solution was evaporated on a water-bath until a crust commenced to be formed. After standing quietly for from three to four hours, most of the 3-nitrophthalic acid separated as a hard crust on the walls of the container. A further small crop was obtained by evaporating the liquid again to two-thirds its bulk. The acid was purified by one recrystallization. Yield, about 50 grams.

Fifty grams of the acid in the state of a fine powder were mixed with 125 grams of phosphorus pentachloride and slowly heated in a casserole in a sulphuric acid bath. Action began at about 110°, the mass boiling violently. The heat was slowly raised to 140° or until the liquid began to develop a red color. On cooling, the reaction product became solid. This was reduced to a fine state of division and extracted with 400 cc. of carbon tetrachloride. After standing over night, most of the nitrophthalyl chloride separated as a mass of crystals somewhat red in color. To purify them they were powdered and crystallized twice from ligroin, boiling-point 60° to 80°. A fine white meal of crystals was obtained. Melting-point, 76°-77° (corr.).

The chloride separated as good-sized compact prisms when an ethereal solution was allowed to evaporate over sulphuric acid.

3-nitrophthalyl chloride is readily soluble in cold ether and chloroform and in warm carbon tetrachloride and ligroin. It is but little soluble in cold carbon tetrachloride or cold ligroin. It is quite stable when in the form of fair-sized compact crystals but is very unstable when in a fine state of division. The solvents used

---

[1] This Journal, **23**, 740.

in its purification must be perfectly dry or there is a considerable loss due to the formation of the anhydride.

Analyses gave the following results:

	Theory for $C_6H_3(NO_2)(COCl)_2$.	Found. I.	Found. II.
Carbon	38.74	39.00	....
Hydrogen	1.21	1.46	....
Nitrogen	5.66	5.91	....
Chlorine	28.55	28.53	28.26

ACTION OF AMMONIA.

Dry Chloride and Dry Ammonia.—A small quantity of the dry chloride was placed in a small flask and a current of dry ammonia passed over it. The reaction was violent, copious clouds of ammonium chloride being given off. The reaction mass became pasty and of a yellow color and very warm. The yellowish mass dissolved readily in a warm mixture of alcohol and acetone, giving small yellow crystals on standing. Melting-point, 213°-215°. Melting-point of 3-nitrophthalimide, 215°-216°.

Chloroform Solution of the Chloride and Dilute Ammonia Water.—A small quantity of the chloride was dissolved in about 75 cc. of chloroform. This was placed in a separatory funnel. Water and small pieces of ice were added and then successive small portions of dilute ammonia water until the odor of ammonia persisted after shaking and standing for ten minutes. The aqueous solution was separated from the chloroform and acidified with hydrochloric acid. Clusters of small, transparent plates separated on standing.

The melting-point of this substance was not constant. It melted to a clear liquid between 150° and 157°, according to rate of heating. A gas was given off at the same time that may have been confined air or a small amount of water coming from the decomposition of the substance. The substance solidified again at about 160° and remelted with vigorous evolution of water between 200° and 205°. When bubbling ceased, the product solidified again, if the temperature had not risen above 210° and remelted finally at 214°-215°, practically the melting-point of the imide. This behavior corresponds in part with that of 3-nitro-1-phthalamic acid.

To prove that it was such, it was transformed into 6-amino-2-

nitrobenzoic acid. The Hofmann method as used by Kahn[1] was followed. 2.1 grams of the amic acid were dissolved in 10 cc. of normal potassium hydroxide solution. The solution was well cooled and to it was added 0.5 cc. of bromine dissolved in 20 cc. of the normal alkali. The whole was well shaken and then treated with 30 cc. more of the alkali. On heating the yellow solution for an hour on a water-bath, its color changed to red. It was then placed in an ice-bath and carefully treated with 20.5 cc. of 2-N-hydrochloric acid, added drop by drop. The yellow mass that separated was crystallized from water. Beautiful leaves or sheaves of needle-like crystals were obtained melting with decomposition at 178°-180°. This corresponds with that of the 6-amino-2-nitrobenzoic acid obtained by Kahn. As a further proof, this body was changed to metanitraniline. One gram was dissolved in 10 cc. of methyl alcohol, and 0.5 cc. of concentrated sulphuric acid was added and the whole heated in a flask connected with a return condenser for seven hours. The reaction product was poured into a small amount of water and neutralized with sodium carbonate. The yellow solid that separated was crystallized twice from hot water. Fine yellow needles were obtained that melted at 112°. The melting-point of metanitraniline is 111°.

Dry Ethereal Solution of the Chloride and Dry Ammonia.—Two to three grams of the chloride were dissolved in 150 cc. of dry ether and placed in a freezing-mixture with a temperature of —5° to —10°. Dry ammonia gas was then passed in, whereupon the solution became milky. After the action was over, a stream of dry hydrochloric acid gas was passed through the mixture until it was no longer absorbed. The whole was filtered with suction. The clear, ethereal solution was diluted with 50 cc. of carbon tetrachloride and allowed to evaporate at room temperature in a current of dry air. Clusters of fine white needles were obtained. Nothing was found in the ethereal solution when the treatment with hydrochloric acid was omitted.

A small portion of this substance was placed in a melting-point tube and heated slowly. It melted to a clear liquid at 99°-100° and solidified again without apparent loss before the temperature reached 105°. It melted again without evolution of gas at 214°-215°.

---

[1] *Ber. d. chem. Ges.*, **35**, 631.

To show that the cyan acid rearranged to the imide without loss, a weighed portion of it was placed in a platinum crucible and heated in an air-bath for thirty minutes to a temperature of 125°. The rearrangement described above took place but the change in weight was less than a milligram. The fused mass was dissolved in a warm mixture of alcohol and acetone and gave crystals of the imide.

A small amount of the cyan acid was dissolved in dry ether, and ammonia gas passed through the solution. A white, amorphous mass was obtained and the ethereal solution left no residue. This body was thought to be the ammonium salt. It lost ammonia and passed to the imide when heated above 200°. No other salts could be formed, as the cyan acid is so unstable in the presence of water.

Hoogewerff and Van Dorp obtained phthalamic acid by the action of concentrated sulphuric acid upon *o*-cyanbenzoic acid. The same experiment was tried with the nitrocyanbenzoic acid but the results were not the same. 3-nitrophthalic acid was the only result.

Action of Water on the Cyan Acid.—Two grams of the acid were dissolved in 25 cc. of warm water. On cooling, thin plates separated. They melted at 140° to 145° with no evolution of water, solidified again and then remelted with evolution of water at 204°-205. The crystals were redissolved in a little water and kept warm, 60°-65°, for an hour. The crystals then obtained showed no sign of rearrangement but melted with evolution of water at 208°-212°. After all water had been driven off, the tube was allowed to cool. The contents were found to be the imide. The acid ammonium salt of 3-nitrophthalic acid was made and compared with the above. They were found to be identical.

Analysis of the nitrocyanbenzoic acid:

	Theory for $C_6H_3(NO_2)CN.COOH$.	Found.
Carbon	50.00	50.16
Hydrogen	2.08	2.10

ACTION OF PRIMARY AROMATIC AMINES UPON 3-NITROPHTHALYL CHLORIDE.

Action of Aniline.—A few grams of the nitrophthalyl chloride were dissolved in dry ether and cooled to —8°. A cold solution of aniline was added very slowly, care being taken to keep the temperature from rising above —5°. A pale yellow solid separated at once. This was filtered off and washed with dilute hydrochloric acid and then with warm water. The white caseous residue was crystallized repeatedly from large amounts of boiling alcohol. The product separated in the form of white, fine needles that felted when filtered. Melting-point, 211°-212°, with decomposition. Analysis, as given below, showed the compound to be 3-nitrophthalanilide. It was insoluble in water, nearly so in cold alcohol, easily soluble in hot alcohol or glacial acetic acid. Prolonged boiling with water had no effect. Dilute sodium carbonate or hydroxide solution had no effect in the cold but liberated aniline when heated.

A small portion was heated for an hour to gentle boiling with glacial acetic acid. On cooling and diluting, crystals separated melting at 135°. Melting-point of 3-nitrophthalanil, 134°.

	Theory for $C_6H_3(NO_2)C_2O_2(NHC_6H_5)_2$.	Found.
Carbon	66.48	66.45
Hydrogen	4.16	4.34
Nitrogen	11.63	11.82

Action of Paratoluidine.—The results obtained by using paratoluidine instead of aniline were perfectly analogous to those described above. The reaction was carried on in a similar manner, the result being a mass of fine, white needles that could not be told from those obtained from aniline. Melting-point, 223°-225°, with decomposition. Analysis showed the compound to be 3-nitrophthal-*p*-toluide.

When heated with glacial acetic acid for a short time it was changed to 3-nitrophthal-*p*-tolil, melting-point, 152°-153°.

Analysis of 3-nitrophthal-*p*-toluide.

	Theory for $C_6H_3(NO_2)C_2O_2(NHC_6H_4CH_3)_2$.	Found.
Nitrogen	10.8	11.0

Action of Metanitraniline.—The experiment was carried on in the same way as with aniline. The reaction was not as rapid.

The reaction-product was finally crystallized from a large amount of alcohol, giving a mass of small, white needles. They melted very poorly at 225° to 230°, with decomposition. Heating for two hours with glacial acetic acid dissolved them but also changed the substance to 3-nitrophthal-*m*-nitranil. Melting-point, 218°-219°.

Analysis of 3-nitrophthal-*m*-nitranilide.

	Theory for $C_6H_3(NO_2)C_2O_2(NHC_6H_4NO_2)_2$.	Found.
Carbon	53.21	53.19
Hydrogen	2.88	2.78

Action of Paranitraniline.—The experiment was carried out in the usual manner. No solid separated from the cold ethereal solution but did when it was allowed to warm to the room temperature. This was purified by the usual process of washing and crystallizing from warm alcohol. Small, warty masses separated. Further crystallization from alcohol gave small, pale yellow needles melting with decomposition at 197°-200°. It was probably a product analogous to those described above. No analysis was made.

Treatment with glacial acetic acid gave fine, yellow needles melting at 248° to 249° with slight decomposition.

The melting-point of 3-nitrophthal-*p*-nitranil obtained by Bogert and Boroschek was 249°.

ORGANIC LABORATORY, HAVEMEYER HALL,
COLUMBIA UNIVERSITY.

THE ACTION OF THE SODIUM SALTS OF DIBASIC ACIDS ON ANILINE HYDROCHLORIDE, AND OF ANILINE ON PHTHALYL CHLORIDE AND SUCCINYL CHLORIDE.

BY FREDERICK L. DUNLAP AND FREDERICK W. CUMMER.

Received March 24, 1903.

IN this Journal,[1] the results of the action of the sodium salts of monobasic acids on the hydrochloride of aniline and of other amines, were reported by one of us. This study has been further extended so as to include the sodium salts of dibasic acids, sodium phthalate and sodium succinate being selected for this experimental work.

When dry sodium phthalate and aniline hydrochloride are heated together, phthalanil is formed, while sodium succinate and aniline hydrochloride produce succinanilide and succinanil. Phthalanil and succinanil are not formed directly from the sodium phthalate or the sodium succinate and the aniline hydrochloride, but they are only the final products, phthalanilide and succinanilide being first formed, then undergoing, at the high temper-

---

[1] This Journal, **24**, 758 (1902).