XV. *Researches into the Chemical Constitution of Narcotine, and of its Products of Decomposition.*—Part I. *By* AUGUSTUS MATTHIESSEN, *F.R.S., Lecturer on Chemistry in St. Mary's Hospital, London, and* G. C. FOSTER, *B.A., Lecturer on Natural Philosophy in Anderson's University, Glasgow.*

Received February 26,—Read March 26, 1863.

§ I.—COMPOSITION OF NARCOTINE AND COTARNINE.

THE existence of Narcotine was indicated by DEROSNE as early as the year 1803, but its chemical nature remained almost entirely unknown until ROBIQUET [*], in 1817, showed that it belonged to the class of vegetable alkaloids. Numerous analyses of narcotine were subsequently published by DUMAS and PELLETIER [†], PELLETIER [‡], LIEBIG [§], REGNAULT [||], and others; but its composition was first determined to the general satisfaction of chemists by BLYTH [¶], who, in 1844, proposed the formula $C_{46}H_{25}NO_{14}$, supporting it by numerous analyses of the double hydrochlorate of narcotine and platinum, and showing, at the same time, that it accorded well with the most trustworthy results of previous investigators, and also accounted satisfactorily for the formation of the remarkable decomposition-products of narcotine discovered by himself and by WÖHLER [**]. Since the publication of BLYTH's investigation, the formula which he proposed has been generally adopted as expressing correctly the composition of this base. More recently, however, WERTHEIM [††], founding his opinion chiefly on the composition of the volatile bases obtained by distilling narcotine with potash, has maintained the existence of two additional varieties of narcotine, homologous with that examined by BLYTH, and represented respectively by the formulæ $C_{44}H_{23}NO_{14}$ and $C_{48}H_{27}NO_{14}$; while HINTERBERGER [‡‡] has analysed a compound of chloride of mercury with what he considers as a fourth variety, still homologous with the preceding, and represented by the formula $C_{42}H_{21}NO_{14}$.

Such being the results of previous investigations, it was plainly necessary to begin any new research into the chemical nature of narcotine by endeavouring to ascertain, by direct analysis, whether there existed in reality more than one kind of narcotine, and,

---

[*] Ann. de Chim. et de Phys. vol. v. p. 275.

[†] Ibid. vol. xxiv. pp. 186 and 191.

[‡] Ibid. vol. l. p. 271.

[§] Jahresbericht über die Fortschritte der physischen Wissenschaften, von Jacob Berzelius, vol. xi. (1832) p. 231.

[||] Ann. de Chim. et de Phys. vol. lxviii. p. 138.

[¶] Memoirs and Proceedings of the Chemical Society, vol. ii. p. 167.

[**] Annalen der Chemie und Pharmacie, vol. l. p. 1.

[††] Journal für praktische Chemie, vol. liii. p. 431.

[‡‡] Annalen der Chemie und Pharmacie, vol. lxxxii. p. 312.

if so, which of these kinds was being operated upon. The following are the results obtained on analysing specimens of narcotine procured from several distinct sources.

A. *Narcotine prepared by* Mr. Morson *from a mixture of various kinds of opium*[*].

I. 0·6311 grm. substance gave 1·4789 grm. carbonic acid and 0·3438 grm. water.
II. ·2372 grm. substance gave ·5552 grm. carbonic acid and ·1234 grm. water.
III. ·2244 grm. substance gave ·5266 grm. carbonic acid and ·1148 grm. water.
IV. ·3258 grm. substance gave ·7576 grm. carbonic acid and ·1682 grm. water.
V. ·7470 grm. substance gave ·1724 grm. platinum.
VI. ·5708 grm. substance gave ·1338 grm. platinum.
VII. ·5555 grm. substance gave ·1304 grm. platinum.
VIII. ·6153 grm. substance gave ·1482 grm. platinum.

B. *Narcotine prepared from Turkish opium by* Dr. G. Merck *of Darmstadt.*

0·3584 grm. substance gave 0·8344 grm. carbonic acid and 0·1847 grm. water.

C. *Narcotine prepared from Egyptian opium by* Dr. G. Merck.

0·3172 grm. substance gave 0·7451 grm. carbonic acid and 0·1630 grm. water.

D. *Narcotine prepared from Persian opium by* Dr. G. Merck.

0·3192 grm. substance gave 0·7460 grm. carbonic acid and 0·1660 grm. water.

E. *Narcotine prepared from Egyptian opium by* Mr. Morson.

0·3460 grm. substance gave 0·8094 grm. carbonic acid and 0·1790 grm. water.

F. *Narcotine from Turkish opium obtained from* Messrs. Hopkin *and* Williams.—(The whole of this sample of narcotine was divided into three portions by fractional crystallization from alcohol: the following analyses were made with crystals of the first and last crops respectively, each of which was considerably smaller in quantity than the intermediate crop.)

I. 0·4046 grm. substance gave 0·9503 grm. carbonic acid and 0·2085 grm. water.
II. ·3366 grm. substance gave ·7843 grm. carbonic acid and ·1730 grm. water.

These numbers correspond to the following percentages:—

	A.				B.	C.	D.	E.	F.		Mean.
	I. & V.	II. & VI.	III. & VII.	IV. & VIII.					I.	II.	
Carbon .	63·91	63·83	64·00	63·42	63·49	64·01	63·74	63·80	64·05	63·55	63·78
Hydrogen	6·05	5·77	5·69	5·74	5·73	5·71	5·77	5·75	5·72	5·71	5·76
Nitrogen .	3·26	3·31	3·32	3·40	——	——	——	——	——	——	3·32
Oxygen .	——	——	——	——	——	——	——	——	——	——	27·14

---

[*] This was the material that served for the greater number of the experiments which follow.

The percentages required by the formula $C_{46}H_{25}NO_{14}$ are—

Carbon	64·63
Hydrogen	5·85
Nitrogen	3·28
Oxygen	26·24

from which the above results differ very considerably: we are therefore led to regard the formula $C_{44}H_{23}NO_{14}$, or preferably $\text{Є}_{22}H_{23}N\Theta_7$, which accords much better with our analyses, as more exact: it corresponds to the following proportions in 100 parts:—

Carbon	63·92
Hydrogen	5·57
Nitrogen	3·39
Oxygen	27·12

And since all the different samples of narcotine which we were able to procure gave on analysis identical results *, we conclude that there is no sufficient evidence of the existence of more than one kind of narcotine, especially as we believe that the observations which formerly gave rise to the contrary opinion are explained by an experiment to be hereinafter described.

If the formula $\text{Є}_{22}H_{23}N\Theta_7$ be adopted for narcotine, it is impossible to account in

---

* The difference between the highest quantity of carbon (F. I.) and the lowest (A. IV.) given by the whole series of analyses amounts to 0·63 per cent.; but this extreme difference among the analyses of seven distinct specimens is scarcely perceptibly greater than the difference (0·58 per cent.) between the highest and lowest (A. III. & IV.) numbers resulting from the analysis of the same specimen. Although these differences are rather high, we believe that they are due entirely to accidental errors of experiment, and chiefly to the difficulty of ensuring the complete combustion of narcotine. No analysis of that substance ever gave us more than 64·05 per cent. of carbon, but several gave smaller quantities than the lowest quoted above (for instance, 62·7, 62·8, 63·1 per cent.); but in these cases traces of unoxidized carbon could always be detected in the combustion-tube after the experiment. The combustions were made with oxide of copper, and, like all those given in this paper, were finished in a stream of oxygen.

The difference between the percentage of nitrogen required by the old formula of narcotine (Blyth's) and by that which we adopt being no greater than the probable errors of analysis, it was not thought worth while to determine that element in more than one sample.

For the sake of comparison, we append here the results obtained by other chemists who have analysed narcotine or its salts.

Analyses of Narcotine.

	Dumas and Pelletier (1823).	Pelletier (1832).	Liebig (1832).	Regnault (1838).			Hofmann (1844).	
Carbon . .	68·88	65·16	64·09	64·01	64·51	64·09	64·53	——
Hydrogen .	5·91	5·45	5·50	5·96	5·99	5·73	6·21	——
Nitrogen . .	7·21	4·31	2·51	3·46	3·52	——	3·30	2·92

	Mulder (1838).				Varrentrapp and Will (1841).	
Nitrogen	3·03	2·98	2·73	2·44	3·77	3·72

Note.—The analyses of Dumas and Pelletier are calculated with the old equivalent of carbon (6·11); Liebig's analysis is given as recalculated by Blyth (Mem. Chem. Soc. vol. ii. p. 167) with the corrected equivalent; Regnault's analyses are similarly recalculated from the original weighings. For all the foregoing, any simple manner for the well-known decomposition of that substance, under the influence of oxidizing agents, into opianic acid and cotarnine, unless the received formula of either one or other of these bodies be also modified.

It seemed impossible to doubt the accuracy of the formula $Ꞓ_{10} H_{10} Ɵ_5$ for opianic acid, but nevertheless, for the sake of greater certainty, we have repeated the analysis of this acid, though with no other result than a fresh confirmation of the admitted formula.

I. 0·2494 grm. acid gave 0·5198 grm. carbonic acid and 0·1066 grm. water.
II. ·1921 grm. acid gave ·4030 grm. carbonic acid and ·0855 grm. water.
III. ·2492 grm. acid gave ·5260 grm. carbonic acid and ·1117 grm. water.

	Calculated.		Found.			
			I.	II.	III.	Mean.
$Ꞓ_{10}$	120	57·14	56·84	57·21	57·57	57·21
H_{10}	10	4·76	4·75	4·95	4·98	4·89
$Ɵ_5$	80	38·10	——	——	——	37·90
$Ꞓ_{10} H_{10} Ɵ_5$	210	100·00				100·00

On the other hand, our analyses of cotarnine lead us to adopt the formula $Ꞓ_{12} H_{13} NƟ_3$

---

see references †, ‡, §, ||, page 1; for Hofmann's analysis see Blyth's memoir (*loc. cit.*); Mulder's results are quoted from Varrentrapp and Will (Ann. Chem. Pharm. vol. xxxix. p. 282).

Analyses of Chloroplatinate of Narcotine.

	Liebig (1838).		Regnault (1839).		Hofmann (1844).		Blyth (1844).		How (1854).
Platinum . .	14·51	14·64	15·81	15·97	15·85	15·80	15·65	15·73	15·88

	Blyth (1844).		Wertheim (1856).				Calculated.	
							$Ꞓ_{22}$.	$Ꞓ_{23}$.
Carbon . .	43·72	43·56	42·92	42·27	42·44	43·17	42·62	43·55
Hydrogen .	4·17	4·30	3·94	4·12	4·14	4·15	3·87	4·14
Platinum .	16·00	15·95	15·95	——	——	15·72	15·98	15·62

Note.—Liebig, Ann. Pharm. vol. xxvi. p. 52; Regnault, Ibid. vol. xxix. p. 60; Hofmann and Blyth, Mem. Chem. Soc. vol. ii. pp. 166, 167; How, Trans. Roy. Soc. Edinb. vol. xxi. p. 31; Wertheim, Traité de Chimie Organique, par M. Charles Gerhardt, vol. iv. p. 67.

Analyses of Hydrochlorate of Narcotine.

	Robiquet (1832).	Regnault (1838).			Regnault (1839).	Calculated.	
						$Ꞓ_{22}$.	$Ꞓ_{23}$.
Hydrochloric acid . .	8·22	8·14	8·17	7·96	7·43	8·12	7·87

Note.—Robiquet, Ann. de Chim. et de Phys. vol. i. p. 231; Regnault, Ibid. vol. lxviii. p. 138, and Ann. Pharm. vol. xxix. p. 60.

Analysis of Chloromercurate of Narcotine.

	Hinterberger (1852). Ann. Chem. Pharm. lxxxii. 312.	Calculated.	
		$Ꞓ_{22} H_{23} NƟ_7$, H Cl, Hg Cl.	$Ꞓ_{23} H_{25} NƟ_7$, H Cl, Hg Cl.
Carbon	43·64	45·13	46·08
Hydrogen	3·90	4·10	4·34
Mercury	18·02	17·09	16·69

in preference to the usual formula, $C_{13}H_{13}NO_3$, which represents that substance as containing one atom of carbon more. The following analyses were made with crystallized cotarnine prepared by the action of dilute nitric acid on narcotine, the method recommended by **Anderson** for the preparation of pure cotarnine: it had a slight yellow or buff colour which it was found impossible to remove.

I. 0·3473 grm. substance gave 0·7746 grm. carbonic acid and 0·2043 grm. water.
II. ·2261 grm. substance gave ·5020 grm. carbonic acid and ·1324 grm. water.
III. ·5633 grm. substance gave ·2320 grm. platinum.
IV. ·5057 grm. substance gave ·2113 grm. platinum.

	Calculated.		Found.					Calculated.
			I.	II.	III.	IV.	Mean.	$C_{13}H_{15}NO_4$.
C_{12}	144	60·76	60·83	60·55	——	——	60·70	62·65
H_{15}	15	6·33	6·54	6·50	——	——	6·52	6·02
N	14	5·90	——	——	5·82	5·91	5·87	5·62
O_4	64	27·01	——	——	——	——	26·86	25·71
$C_{12}H_{13}NO_3, HO_2$	237	100·00					100·00	100·00

V. 0·6619 grm. substance lost 0·0493 grm. water at 110° C.
VI. ·5450 grm. substance lost ·0406 grm. water at 110° C.

	Calculated.		Found.		Calculated.
			V.	VI.	C_{13}.
$C_{12}H_{13}NO_3$	219	92·41	——	——	92·77
H_2O	18	7·59	7·45	7·45	7·23
$C_{12}H_{13}NO_3, H_2O$	237	100·00			100·00

These results are confirmed by the following determinations of the proportion of platinum in chloroplatinate of cotarnine, dried *in vacuo* over sulphuric acid*:

I. 0·4312 grm. salt gave 0·1005 grm. platinum.
II. ·3161 grm. salt gave ·0732 grm. platinum.
III. ·4000 grm. salt gave ·0924 grm. platinum.

	Calculated.		Found.		
	C_{12}.	C_{13}.	I.	II.	III.
Platinum per cent	23·3	22·6	23·3	23·2	23·1

The adoption of the formula $C_{12}H_{13}NO_3$† for cotarnine enables us to represent its

---

* Five platinum-determinations, made with chloroplatinate of cotarnine that had been dried in the water-bath, gave quantities of platinum varying from 23·5 to 23·9 per cent., numbers which differ even more than those quoted in the text from that required by the hitherto admitted formula. The substances used for analyses II. and III. were prepared from two distinct specimens of cotarnine: the salt II. was, moreover, precipitated in presence of excess of bichloride of platinum, salt III. in presence of excess of hydrochlorate of cotarnine.

† The formula originally proposed for cotarnine by **Wöhler**, but which he himself only regarded as provisional, was $C_{26}H_{13}NO_5$; **Blyth**'s formula was $C_{25}H_{13}NO_6$; the formula $C_{13}H_{13}NO_3$ was proposed by **Gerhardt** (Précis de Chimie Organique, 1845, vol. ii. p. 298).

formation by the action of oxidizing agents on narcotine, by means of a very simple equation,—

$$\underset{\text{Narcotine.}}{C_{22}H_{23}NO_7} + O = \underset{\text{Cotarnine.}}{C_{12}H_{13}NO_3} + \underset{\text{Opianic Acid.}}{C_{10}H_{10}O_5},$$

and, as will be shown hereafter, it is further supported by the manner in which cotarnine is decomposed by nitric and hydrochloric acids.

Assuming the accuracy of the formulæ here proposed as sufficiently established, we next endeavoured to ascertain the chemical constitution of narcotine by studying the action of various reagents on cotarnine and on its other principal derivative, opianic acid. Hitherto we have made but few experiments on the action of reagents on narcotine itself, from the conviction that their results would hardly be intelligible without a previous knowledge of the transformations of the bodies into which it splits up with so much ease.

It appears, as the result of a good many trials, that the following is perhaps the most advantageous method of transforming narcotine into opianic acid and cotarnine. 100 grms. of narcotine are dissolved in a considerable excess of dilute sulphuric acid (150 grms. acid and 1500 grms. water), the solution is heated to boiling, and 150 grms. finely powdered peroxide of manganese* is then added as quickly as possible, care being taken that it does not cause the liquid to froth over; when the whole quantity of peroxide of manganese has been added, the mixture is quickly filtered through a funnel surrounded by boiling water. The filtrate, on cooling, becomes half-solid, from the separation of crystals of opianic acid, and by twice recrystallizing this product from boiling water it is obtained sufficiently pure for most purposes, though still retaining a slight brownish-yellow colour, which can be got rid of, when needful, by boiling the acid with a dilute solution of hypochlorite of sodium, in the manner indicated by WÖHLER.

The cotarnine contained as sulphate, together with a large quantity of sulphate of manganese in the original mother-liquor of the opianic acid, may be conveniently extracted therefrom as follows. The mother-liquor is mixed with a quantity of milk of lime sufficient to neutralize the free sulphuric acid and to precipitate part of the manganese, then, without filtering, an excess of carbonate of sodium is added and the whole is heated to boiling for a few minutes, in order to precipitate completely the manganese and lime (or the neutralization and precipitation may be effected entirely by means of carbonate of sodium, without using lime). The mixture is then filtered, first through calico and afterwards, if needful, through paper; the filtrate is neutralized with dilute sulphuric acid, evaporated rapidly to a small bulk, allowed to cool completely, poured off from any sulphate of sodium that may have crystallized out, and finally mixed with an excess of strong potash- or soda-lye, whereby the cotarnine is precipitated.

It is a matter of some importance for the successful preparation of cotarnine in this manner, that its extraction from the original mother-liquors containing it should be

---

* 100 parts of our oxide of manganese corresponded to 60 parts of pure peroxide.

proceeded with without much delay, otherwise the quantity obtained is small and its colour dark. Under all circumstances the odour of ammonia, or methylamine, is perceptible on adding potash for the final precipitation of the cotarnine; and this odour is strongest when a long time has elapsed during the previous parts of the process. The decomposition which is thus indicated appears to lessen the amount of product obtained in two ways: not only is the quantity of cotarnine existing in the solution diminished by the amount that has suffered decomposition, but the resulting volatile alkali seems to prevent the precipitation of the unaltered base.

Cotarnine that is very dark-coloured may be decolorized, to a considerable extent, by dissolving it in hydrochloric acid, digesting the solution upon bone-charcoal, and re-precipitating with potash; but we have never, by any process, succeeded in obtaining cotarnine quite without colour.

§ II.—DECOMPOSITIONS AND DERIVATIVES OF OPIANIC ACID.

1. *Action of Hydrochloric Acid.*—When opianic acid is heated with three or four times its weight of ordinary strong hydrochloric acid, either to 100° C. in a sealed tube, or to the boiling-point of the acid in an open vessel, it is decomposed with evolution of chloride of methyl and carbonic acid, and on evaporating the remaining solution, first on the water-bath, then at the common temperature over lime and sulphuric acid, a residue is obtained which appears to consist of three distinct crystallizable substances; but the ease with which at least one of them undergoes alteration by heat or exposure to air, and the difficulty of completely separating them from each other, have hitherto prevented us from making a thorough examination of these products, and we therefore postpone to a future communication any further description of them*.

Opianic acid seems to undergo a similar decomposition when boiled with fuming *hydriodic acid*; in this case iodide of methyl is given off, without separation of iodine, but we have not found it possible to remove the excess of hydriodic acid from the residue without destroying the organic constituents.

2. *Action of Potash.*—When opianic acid is mixed with a large excess of potash-lye, and the liquid is evaporated nearly to dryness, the acid splits up into meconin and hemipinic acid. No blackening occurs unless too small a quantity of potash is employed; but when a certain degree of concentration is reached, the decomposition appears to take place almost instantaneously: the mixture, which up to that point is a thick fluid,

---

* According to Wöhler, opianate of ethyl is not formed when a solution of opianic acid in alcohol is saturated with hydrochloric acid. The experiments described in the text made it seem probable that the non-formation of opianic ether under these circumstances might be owing to the decomposition of the opianic acid; but, on sealing up opianic acid with an alcoholic solution of hydrochloric acid and heating it in the water-bath for an hour, it was found that opianate of ethyl was formed in abundance. The ether was precipitated by pouring the contents of the tube into water, and purified by crystallization from alcohol. Thus obtained, it formed hemispherical masses of brilliantly white radiating needles, insoluble in water or dilute alkalis, melting to a colourless oil under hot water, and easily soluble in alcohol and ether. In the dry state it melts at 88° C.

suddenly becomes nearly solid, and as soon as this change has occurred, no more opianic acid can be detected in the mass. The decomposition may even be effected, without the application of external heat, by simply mixing opianic acid with a very strong and warm solution of potash.

In an experiment made in order to ascertain the proportions in which meconin and hemipinic acid are formed in this reaction, 42 grms. of opianic acid yielded

	13·5	grms. pure meconin,
	18·5	grms. pure hemipinic acid (weighed as hemipinate of ammonium),
	4·7	grms. meconin and hemipinic acid mixed,
	5·0	grms. uncrystallizable residue.
Total . .	41·7	grms.

In another experiment, a small quantity of the mixture of opianic acid and potash was boiled down in a small flask, fitted with a glass tube about a yard long, bent vertically downwards just outside the cork, and dipping by its lower end into mercury. When the reaction had taken place, the flask was allowed to cool, and the mercury then rose in the vertical tube to within about an inch of the height of the barometer at the time; thus proving that no permanent gas had been evolved. Hence the following equation—according to which 42 grammes opianic acid should yield 19·4 grammes meconin and 22·6 grammes hemipinic acid—may be taken to represent the decomposition:—

$$\underset{\text{Opianic acid.}}{2\,C_{10}H_{10}O_5} = \underset{\text{Meconin.}}{C_{10}H_{10}O_4} + \underset{\text{Hemipinic acid.}}{C_{10}H_{10}O_6}.$$

The following process was adopted for the purification of the meconin and hemipinic acid thus formed. The alkaline mass obtained by heating opianic acid with potash, was dissolved in a moderate quantity of warm water and mixed with an excess of hydrochloric acid: in this way the meconin was caused to separate out as an oil and to carry down most of the hemipinic acid. After the acidified liquid had been allowed to cool completely, it was poured off from the solid cake of meconin and hemipinic acid which had formed at the bottom, and evaporated to a small bulk, so as to cause the separation of the greater part of the chloride of potassium; this was washed with alcohol; the alcoholic washings were mixed with the concentrated mother-liquor, and the fresh quantity of chloride of potassium which was thus precipitated was removed by filtration or decantation, and the clear liquid was evaporated on the water-bath nearly to dryness; the residue thus obtained was again treated with alcohol, in order to separate the last portions of chloride of potassium, and the alcoholic solution filtered and evaporated. The product of these operations, together with the original precipitate of meconin and hemipinic acid, was next dissolved in boiling water and the solution made slightly alkaline with ammonia. Nearly the whole of the meconin then crystallized out as the solution cooled, and was obtained quite pure by recrystallization from water; the hemipinic acid, on the other hand, remained in solution as hemipinate of ammonium, together with a small quantity of meconin; for although this substance dissolves only very slightly in cold water, it is perceptibly more soluble in a solution of hemipinate of ammonium. In order therefore to complete the purification of the hemipinic acid, the solution of its ammonium-salt was precipitated with acetate of lead, and the hemipinate of lead, after being thoroughly washed, was decomposed under water by hydrosulphuric acid.

Meconin and hemipinic acid thus prepared were found to have all the properties ascribed to them by previous observers. Their identity was further established by analysis.

Analyses of Meconin.

I. 0·2640 grm. substance, dried at 100°, gave 0·5938 grm. carbonic acid and 0·1264 grm. water.

II. 0·3078 grm. substance, dried *in vacuo*, gave 0·6928 grm. carbonic acid and 0·1464 grm. water.

	Calculated.		Found.	
			I.	II.
C_{10}	120	61·85	61·34	61·39
H_{10}	10	5·15	5·32	5·28
Θ_4	64	33·00	——	——
$C_{10}H_{10}\Theta_4$ . .	194	100·00		

Chloromeconin was prepared from this product by treating it in aqueous solution with hypochlorite of sodium and hydrochloric acid.

I. 0·1940 grm. chloromeconin gave 0·1213 grm. chloride of silver.

II. ·2920 grm. chloromeconin gave ·1861 grm. chloride of silver.

	Calculated.	Found.	
	$C_{10}H_9Cl\Theta_4$.	I.	II.
Chlorine per cent.	15·54	15·46	15·76

Nitromeconin was also prepared, but not analysed.

Analyses of Hemipinic Acid.

I. 0·3234 grm. acid, dried at 100°, gave 0·6286 grm. carbonic acid and 0·1361 grm. water.

II. 0·3980 grm. acid gave 0·7748 grm. carbonic acid and 0·1654 grm. water.

	Calculated.		Found.	
			I.	II.
C_{10}	120	53·10	53·01	53·09
H_{10}	10	4·42	4·68	4·62
Θ_6	96	42·48	——	——
$C_{10}H_{10}\Theta_6$ . .	226	100·00		

1·3447 grm. air-dry acid lost 0·1862 grm. at 100°.

	Calculated. $C_{10}H_{10}O_6\,2H_2O$.	Found.
Water per cent.	13·50	13·85

The *silver-salt* of this acid was found to have the composition and properties of hemipinate of silver.

I. 0·3855 grm. salt gave 0·1885 grm. silver.

II. ·4225 grm. salt gave ·2060 grm. silver.

	Calculated.	Found.	
	$C_{10}H_8Ag_2O_6$.	I.	II.
Silver per cent. . . .	49·09	48·90	48·76

3. *Action of Nascent Hydrogen.*—When an aqueous solution of opianic acid is warmed for several hours with sodium-amalgam, the subsequent addition of hydrochloric acid causes a precipitate of meconin. The formation of meconin is not due, in this case, to the decomposition of the opianic acid by the soda formed from the sodium-amalgam; for it takes place in a dilute solution, and at a temperature very much below that at which opianic acid is decomposed under the influence of alkali; the quantity of meconin formed from a given weight of acid is also considerably greater than that produced under the latter circumstances; for instance, 5 grms. opianic acid gave 3·65 grms. pure meconin, whereas 5 grms. opianic acid decomposed by alkali would yield 2·3 grms. meconin and 2·7 grms. hemipinic acid. The barely possible supposition that the additional quantity of meconin is owing to the reduction of hemipinic acid formed in a previous stage of the reaction is excluded by the fact that hemipinic acid is not acted on by sodium-amalgam in presence of water. Moreover opianic acid is similarly converted into meconin by the action of zinc and dilute sulphuric acid. Hence the transformation consists in a direct reduction or deoxidation of the acid under the influence of nascent hydrogen.

$$\underset{\text{Opianic acid.}}{C_{10}H_{10}O_5} + H_2 = \underset{\text{Meconin.}}{C_{10}H_{10}O_4} + H_2O.$$

According to this equation, 5 parts of opianic acid correspond to 4·6 parts of meconin.

Of the two following analyses, the first was made with the product of the action of sodium-amalgam, the second with that of the action of zinc and dilute sulphuric acid on opianic acid; this latter product retained a slight colour, even after being several times recrystallized, and was obviously not quite pure.

I. 0·3906 grm. substance gave 0·8845 grm. carbonic acid and 0·1834 grm. water.

II. ·3760 grm. substance gave ·8348 grm. carbonic acid and ·1694 grm. water.

	Calculated.		Found.	
			I.	II.
C_{10}	120	61·85	61·76	60·55
H_{10}	10	5·15	5·22	5·01
O_4	64	33·00	——	——
$C_{10}H_{10}O_4$ . .	194	100·00		

Chemists have long been aware of the simple relation subsisting between the formulæ of

Meconin . . . . $C_{10}H_{10}O_4$,
Opianic acid . . . . . $C_{10}H_{10}O_5$,
and
Hemipinic acid . . . . $C_{10}H_{10}O_6$;

the foregoing experiments prove that this relation is not confined to the formulæ, but that the bodies themselves are intimately connected. Hence it was evident that, in order to arrive at a knowledge of the constitution of opianic acid, the chemical nature of the other two members of the group must also be examined. The experiments which we have made in this direction are still very far from complete; they relate principally to the action of acids on meconin and hemipinic acid, and the following are the most important results yet obtained.

Action of Hydriodic and Hydrochloric Acids on Meconin.—When meconin is boiled with concentrated hydriodic acid, a considerable quantity of iodide of methyl is formed, but the other products of the reaction are so unstable that it has not been found possible to remove the excess of hydriodic acid without completely destroying them. It was not till after many attempts to purify the products thus formed that it was found that meconin undergoes a similar decomposition when heated in a sealed tube, to a little above 100°, with three times its weight of strong hydrochloric acid. The chloride of methyl, formed under these circumstances, quickly volatilizes when the tube is opened, and by careful evaporation, over lime and sulphuric acid, a crystalline residue may be obtained, whence it is possible to remove completely the excess of hydrochloric acid; but it has not yet been further investigated.

Action of Hydriodic Acid on Hemipinic Acid.—Hemipinic acid is decomposed, when boiled with concentrated hydriodic acid, into carbonic acid, iodide of methyl (boiling-point 42°·8 C., vapour-density 5·05; calculated vapour-density 4·92), and an acid of the formula $C_7H_6O_4$. It will be seen that the composition of this acid is intermediate between that of salicylic acid, $C_7H_6O_3$, and that of gallic acid, $C_7H_6O_5$, and, as will be seen by the description which follows, it is analogous to these acids in some of its properties. Accordingly, in order to recall the fact of its containing one atom of oxygen less than gallic acid, we propose to name it provisionally *hypogallic acid*, reserving to ourselves to suggest, if possible, a more appropriate name when its chemical relations shall have been more thoroughly investigated. The reaction, by which these products are formed, takes place according to the equation

$$\underset{\text{Hemipinic acid.}}{C_{10}H_{10}O_6} + 2HI = CO_2 + \underset{\text{Iodide of methyl.}}{2CH_3I} + \underset{\text{Hypogallic acid.}}{C_7H_6O_4}.$$

Hypogallic acid, when pure, is only slightly soluble in cold water, but dissolves easily in hot water, alcohol, and ether; its solution reacts strongly acid with litmus-paper. It separates from hot water in small prismatic crystals, united into stellate groups, and containing 1½ atom water of crystallization, which they lose at 100°. The acid melts at about 180°, but, as it begins to decompose even at a lower temperature, its melting-point could not be accurately ascertained. Dried at 100° C., it gave the following results on analysis:—

I. 0·3465 grm. substance gave 0·6904 grm. carbonic acid and 0·1238 grm. water.
II. ·4670 grm. substance gave ·9326 grm. carbonic acid and ·1662 grm. water.
III. ·4968 grm. substance gave ·9900 grm. carbonic acid and ·1710 grm. water.

	Calculated.		Found.		
			I.	II.	III.
C_7	84	54·55	54·34	54·46	54·35
H_6	6	3·89	3·97	3·95	3·82
Θ_4	64	41·56	—	—	—
$C_7H_6\Theta_4$ . .	154	100·00			

I. 1·486 grm. crystallized acid lost 0·2200 grm. at 100° C.
II. 2·132 grms. crystallized acid lost ·3120 grm. at 100°.
III. 1·138 grm. crystallized acid lost ·1716 grm. at 100°.

	Calculated.		Found.		
			I.	II.	III.
$C_7H_6\Theta_4$	154	85·08	—	—	—
$H_3\Theta_{1\frac{1}{2}}$	27	14·92	14·80	14·63	15·08
$C_7H_6\Theta_4, 1\frac{1}{2}H_2\Theta$ . .	181	100·00			

Hypogallic acid gradually turns brown when heated in the air to a little above 100° C.; the same change occurs more quickly when a solution of it, especially if neutral or alkaline, is evaporated. Added to solution of *nitrate* or *ammonio-nitrate of silver*, it causes an immediate precipitation of metallic silver, even in the cold; with *sulphate of copper* and a slight excess of potash it gives a yellowish-green solution from which an orange-yellow precipitate is thrown down on warming; in a mixture of *sesquichloride of iron and red prussiate of potash*, it immediately produces a blue precipitate; when boiled with solution of *corrosive sublimate*, it reduces it to calomel. With *sesquichloride of iron*, it gives an intense indigo-blue coloration, which is changed to violet by a very small quantity of ammonia, and to blood-red by excess of ammonia, no precipitate being produced, unless too much chloride of iron has been used; the colour is destroyed by strong acids, but restored by neutralization with alkali, and partially by addition of water. A solution of the acid immediately becomes brown on addition of *alkali*, the colour quickly becoming darker by exposure to the air. With *ammonia and chloride of barium* or *calcium*, it gives a dirty brown flocculent precipitate; with *acetate of lead*, a pale yellow precipitate.

Hypogallic acid is decomposed by heat into carbonic acid and a substance which solidifies in the neck of the retort to a colourless crystalline mass. The decomposition begins at about 170° C., and goes on rapidly at 200°. The crystalline product melts, in the crude state, at about 90° C.; it dissolves easily in water and crystallizes in needles when the solution is evaporated. It is rapidly attacked by nitric acid, even when diluted, giving a red-brown solution. With sesquichloride of iron it gives a bluish-black amorphous precipitate; with acetate of lead it gives a white or yellowish-white precipitate, soluble in an excess of acetic acid. It slowly assumes a darker colour by exposure to air in contact with alkali. This substance has not yet been prepared in sufficient quantity for complete investigation.

In addition to hypogallic acid, no less than three other acids are known, having the same composition, and resembling it to a remarkable degree in some of their most characteristic properties. They are carbohydrochinonic acid* (obtained by OTTO HESSE by the action of bromine in presence of water on chinic acid), protocatechuic acid† (obtained by STRECKER as a product of the action of fused potash on piperic acid), and oxysalicylic acid‡ (obtained by LAUTEMANN by decomposing iodosalicylic acid with potash). All these acids are described as having about the same solubility in water, alcohol, and ether as hypogallic acid; like it, they all give a dark coloration with the smallest trace of sesquichloride of iron, they all reduce nitrate of silver, they all become dark brown when mixed with alkali and exposed to the air, all give a yellowish-white precipitate with acetate of lead, and at a high temperature they are all decomposed into carbonic acid and oxyphenic acid or hydrochinone§. Nevertheless no two of these acids appear to have quite the same properties. The following are the most important points in which differences have been observed. Hypogallic acid crystallizes with 1½ molecule of water (14·9 per cent.), carbohydrochinonic and protocatechuic acids with 1 molecule (10·4 per cent.), and oxysalicylic acid without water. Hypogallic and oxysalicylic acids give a dark blue colour with sesquichloride of iron, the other two acids a dark green colour. Hypogallic acid reduces nitrate of silver immediately in the cold; carbohydrochinonic acid reduces it slowly in the cold, rapidly when boiled; oxysalicylic acid has no action on nitrate of silver in the cold, but reduces it completely when boiled. Carbohydrochinonic acid reduces cuprous oxide from a mixture of cupric acetate, tartaric acid, and excess of potash; protocatechuic acid causes no reduction of the same solution. Hypogallic acid causes a precipitate in a mixture of chloride of barium and ammonia; protocatechuic acid only on addition of alcohol.

Whether some of these differences may not be due to accidental causes, depending on the different sources and modes of preparation of the several acids, is a question that readily suggests itself, but it can be answered only by further investigation.

---

* Annalen der Chemie und Pharmacie, vol. cxii. p. 52 (1859); vol. cxiv. p. 292; vol. cxxii. p. 221.

† Ibid. vol. cxviii. p. 280.

‡ Ibid. vol. cxviii. p. 372; more fully vol. cxx. p. 311.

§ The product obtained by the action of heat on hypogallic acid does not fully agree in its reactions with either of these bodies, so far as yet examined.

Action of Hydrochloric Acid on Hemipinic Acid.—Hemipinic acid is rapidly decomposed when heated with two or three times its weight of strong hydrochloric acid, either in a sealed tube to about 110° or in an open vessel connected with a condenser so arranged that the condensed vapour flows back into the mixture, and with an apparatus for evolving gaseous hydrochloric acid, whereby the liquid can be kept constantly saturated with that acid. The products of the reaction are chloride of methyl, carbonic acid, and an acid crystallizing in beautiful long transparent prisms.

This acid is almost insoluble in cold water, and not much more soluble in boiling water; alcohol and ether dissolve it more easily. When heated it begins to sublime, without decomposition, at about 200° C., and supports a temperature of more than 245° without any further change, though at a still higher temperature it melts, and solidifies again on cooling to a crystalline mass. It dissolves in strong sulphuric acid, and is precipitated unchanged on addition of water. It gives no coloration with sesquichloride of iron; with nitrate of silver it gives a white precipitate, which blackens on boiling. It gave, on analysis, numbers agreeing nearly with the formula $C_8 H_8 O_4$.

0·2747 grm. substance gave 0·5702 grm. carbonic acid and 0·1277 grm. water.

	Calculated.		Found.
C_8	96	57·14	56·64
H_8	8	4·76	5·17
O_4	64	38·10	——
$C_8 H_8 O_4$ . .	168	100·00	

The formation of this body therefore probably takes place in accordance with the equation

$$\underset{\text{Hemipinic acid.}}{C_{10} H_{10} O_6} + HCl = CO_2 + CH_3Cl + C_8 H_8 O_4.$$

We hope to give a more complete description of it in a future communication.

By the prolonged action of hydrochloric acid on the mother-liquor from which this acid has crystallized, hypogallic acid appears to be formed. The product thus obtained has not yet been analysed, but it is identical in all its qualitative reactions with that formed by the action of hydriodic acid on hemipinic acid.

Nascent Hydrogen, resulting from the action of sodium-amalgam on an aqueous solution of hemipinic acid, leaves that acid unacted upon, as has been already stated. A portion of hemipinic acid that had been subjected for a long time to the action of sodium-amalgam was converted into silver-salt, the salt being precipitated in two fractions. Both portions, as shown by the following analyses, consisted of pure hemipinate of silver, and no other organic substance than hemipinic acid could be detected in the solution.

I. 0·7050 grm. salt (first precipitate) gave 0·3466 grm. silver.
II. ·2655 grm. salt (second precipitate) gave ·1302 grm. silver.

	Calculated.	Found.	
	$C_{10}H_8Ag_2O_6$.	I.	II.
Silver per cent.	49·10	49·16	49·04

We may here mention a peculiar property of hemipinate of barium which does not seem to have been before observed, but which has often been of service to us as affording the means of recognizing hemipinic acid when present only in small quantity.

When a solution of hemipinic acid is neutralized with baryta-water, or when solutions of hemipinate of ammonium and chloride of barium are mixed together, the liquid remains clear for a long while if left to itself; but if it is boiled for a short time, small, shining, crystalline plates of hemipinate of barium are precipitated and soon fill the whole liquid, if the solutions used were not too dilute. On allowing the liquid to cool, it redissolves this precipitate, and becomes almost or quite clear; but after standing for a few hours, or for a day or two, according as more or less of the salt is contained in it, it again deposits hemipinate of barium, but this time in the form of feathery tufts of very small silky needles; if the liquid be now again heated, these feathery crystals dissolve, and the crystalline plates already mentioned make their appearance once more.

§ III.—DECOMPOSITIONS AND DERIVATIVES OF COTARNINE.

1. *Action of Nitric Acid.*—By gently heating cotarnine with dilute nitric acid, we have obtained nitrate of methylamine and a new acid, *cotarnic acid*, but have not hitherto found out the conditions necessary for the certain production of the latter substance, many attempts to obtain it having been completely unsuccessful.

Cotarnic acid dissolves easily in water, giving a solution which reacts strongly acid with litmus-paper: it dissolves to a less extent in alcohol, and is precipitated from its alcoholic solution by ether. It yields no trace of cyanide when heated with metallic sodium in excess, and is thus proved to contain no nitrogen. It gives a white precipitate with acetate of lead, and is not affected by sesquichloride of iron. Nitrate of silver throws down a very stable silver-salt, which may be crystallized from boiling water, in which it is slightly soluble, without alteration. This salt contains $C_{11}H_{10}Ag_2O_5$.

I. 0·2513 grm. salt gave 0·2693 grm. carbonic acid, 0·049 grm. water, and 0·1235 grm. silver.

II. ·2065 grm. salt gave 0·2279 grm. carbonic acid, 0·0403 grm. water, and 0·1019 grm. silver.

	Calculated.		Found.	
			I.	II.
C_{11}	132	30·14	29·22	30·10
H_{10}	10	2·27	2·16	2·17
Ag_2	216	49·32	49·14	49·35
O_5	80	18·27	——	——
$C_{11}H_{10}Ag_2O_5$ . .	438	100·00		

Hence cotarnic acid must contain $C_{11}H_{12}O_5$, and its formation from cotarnine must take place according to the equation

$$\underset{\text{Cotarnine.}}{C_{12}H_{13}NO_2} + 2H_2O = \underset{\text{Cotarnic acid.}}{C_{11}H_{12}O_5} + \underset{\text{Methylamine.}}{CH_5N}.$$

The formation of methylamine in this reaction was proved by the analysis of its chloroplatinate.

0·3408 grm. salt gave 0·1407 grm. platinum.

	Calculated. $CH_5N, HCl, PtCl_2$.	Found.
Platinum per cent. . . .	41·7	41·3

Cotarnine heated with undiluted nitric acid was found to yield oxalic and apophyllic acids, in accordance with the statements of WÖHLER and ANDERSON.

2. *Action of Hydrochloric Acid.*—Cotarnine heated with three times its weight of strong hydrochloric acid to about 140° C., in a sealed tube, is decomposed into chloride of methyl—identified, *inter alia*, by its formation of the solid hydrate described by BÄYER [*]—and a substance which crystallizes in very small, pale yellow, silky needles. This body we designate, provisionally, *hydrochlorate of cotarnamic acid*, assigning to it the formula $C_{11}H_{13}NO_4$, HCl, which, though not agreeing perfectly with the analyses hitherto obtained, expresses their results more closely than any other formula that seems equally probable. The substance was purified for analysis by several crystallizations from water slightly acidulated with hydrochloric acid, and was dried *in vacuo* over lime and sulphuric acid.

I. 0·3295 grm. substance gave 0·6020 grm. carbonic acid and 0·1729 grm. water.
II. ·4046 grm. substance gave ·7429 grm. carbonic acid and ·2017 grm. water.
III. ·3378 grm. substance gave ·6182 grm. carbonic acid and ·1745 grm. water.
IV. ·3649 grm. substance gave ·1480 grm. platinum.
V. ·4826 grm. substance gave ·2760 grm. chloride of silver.
VI. ·5674 grm. substance gave ·3220 grm. chloride of silver.
VII. ·4590 grm. substance gave ·2626 grm. chloride of silver.
VIII. ·4654 grm. substance gave ·2593 grm. chloride of silver.
IX. ·3712 grm. substance gave ·2128 grm. chloride of silver.
X. ·5200 grm. substance gave ·2905 grm. chloride of silver.

	Calculated.		Found.						Mean.
			I.,IV.&V.	II.&VI.	III.&VII.	VIII.	IX.	X.	
C_{11}	132	50·87	49·83	50·08	49·91	——	——	——	49·94
H_{14}	14	5·40	5·83	5·54	5·74	——	——	——	5·70
N	14	5·40	5·73	——	——	——	——	——	5·73
O_4	64	24·65	——	——	——	——	——	——	24·61
Cl	35·5	13·68	14·15	14·04	14·15	13·78	14·18	13·82	14·02
$C_{11}H_{13}NO_4$, HCl .	259·5	100·00							100·00

---

[*] Annalen der Chemie und Pharmacie, vol. ciii. p. 183.

Assuming for the present the accuracy of the proposed formula, the action of hydrochloric acid on cotarnine will be represented by the following equation:—

$$C_{12}H_{13}NO_3+H_2O+2HCl=CH_3Cl+C_{11}H_{13}NO_4, HCl.$$

Cotarnine. Hydrochlorate of cotarnamic acid.

Hydrochlorate of cotarnamic acid is only slightly soluble in cold water, but is very soluble in hot water; it is less soluble in alcohol than in water, and almost insoluble in ether. When dissolved in hot water, it always undergoes partial decomposition, as is indicated by the separation of an orange-coloured granular precipitate if the quantity of water used is only moderate; when more water is employed, this precipitate remains dissolved, the smallest trace imparting a bright orange-colour to the solution. A similar precipitate (cotarnamic acid, $C_{11}H_{13}NO_4$?) is thrown down on cautiously adding an alkali, or alkaline carbonate or sulphite, to an aqueous or slightly acid solution of hydrochlorate of cotarnamic acid; this precipitate regenerates the original compound when treated with hydrochloric acid; it dissolves with orange-colour in excess of alkali, giving a solution that rapidly becomes brown in the air; by washing with water, out of contact with air, it may be obtained quite free from chlorine. The hydrochlorate dissolves without alteration in water containing a small quantity of free hydrochloric acid; the solution, which is but slightly coloured at first, gradually acquires a beautiful dark-green colour by exposure to the air. If nitric acid is slowly added to a solution of the compound in boiling water, the portions of the liquid with which the acid comes in contact assume a fine opaque crimson colour when seen by reflected light, but appear of a transparent orange tint when seen by transmitted light. After a few minutes a slight effervescence takes place, and this effect disappears. Hydrochlorate of cotarnamic acid mixed with a slight excess of dilute sulphuric acid, and evaporated nearly to dryness on a water-bath, acquires a fine crimson colour rivalling that of acetate of rosaniline; this colour is destroyed by addition of water, but it appears again when the water is evaporated. Nitrate of silver added in excess to a hot solution of the hydrochlorate is rapidly reduced.

Hydriodic and *sulphuric acids* appear to act upon cotarnine in the same way as hydrochloric acid. With hydriodic acid iodide of methyl is formed in unmistakable quantity: the formation of a methyl-compound by the action of sulphuric acid was not proved, but in both cases appropriate treatment of the resulting solutions yielded hydrochlorate of cotarnamic acid with all its characteristic properties above described. Analyses of specimens prepared in this way are included among those already given (page 360).

We have not yet obtained cotarnamic acid itself, nor any of its compounds except the hydrochlorate, in a state that invited analysis; but we hope to be able to do so on continuing our experiments, and thus to remove any uncertainty that may at present exist as to the true formula of this substance.

3. *Action of Potash.*—Cotarnine distilled with caustic potash yields ammonia and

methylamine, but apparently no di- or tri-methylamine or other similar compounds. The ammonia and methylamine were separated by treating their hydrochlorates with absolute alcohol in the usual way. The chloroplatinate of the latter was analysed.

0·3423 grm. salt gave 0·1413 grm. platinum.

	Calculated. $ꞒH_5N, HCl, PtCl_2$.	Found.
Platinum per cent. . .	41·7	41·3

§ IV.—CONCLUSION.

The conclusions which the foregoing experiments enable us to draw, relatively to the constitution of narcotine and its derivatives, are far from being sufficiently comprehensive and precise to admit of expression by a series of rational formulæ; nevertheless it may be allowable to recapitulate briefly the chief points which we think have been established, and to offer some suggestions towards the interpretation of the results that have been obtained.

1. Our analyses indicate the existence of only one kind of narcotine—that, namely, which contains $Ꞓ_{22}H_{23}NΘ_7$. It has already been stated (page 345) that this formula was assigned by WERTHEIM to "methyl-narcotine," which he believed to be only one of several varieties of the base; in addition he recognized, on the authority of BLYTH'S investigation, the existence of "ethyl-narcotine," $Ꞓ_{23}H_{25}NΘ_7$; and in consequence of having obtained a volatile base, of the composition of propylamine, $Ꞓ_3H_9N$, by distilling narcotine with potash, he also admitted the existence of "propyl-narcotine," $Ꞓ_{24}H_{27}NΘ_7$.

In a note near the beginning of this paper, the results of all the published analyses we have been able to find are put together. These results do not appear to us to afford any strong evidence that other chemists have operated upon a kind of narcotine different from that represented by the formula $Ꞓ_{22}H_{23}NΘ_7$; and we think that the following experiment shows that such a supposition is not required to explain the observation which caused the existence of propyl-narcotine to be admitted.

By distilling 20 grammes of narcotine with an excess of concentrated hydriodic acid, we obtained 19 grammes of pure iodide of methyl, a quantity which is nearly in the proportion of three molecules of iodide of methyl to one molecule of narcotine

$$(Ꞓ_{22}H_{23}NΘ_7 : 3ꞒH_3I :: 413 : 436 :: 20 : 21{\cdot}1).$$

Narcotine therefore contains three atoms of methyl so combined as to be easily separated, and hence we think it likely that WERTHEIM'S supposed propylamine was the isomeric trimethylamine. This experiment makes it also seem probable that the distillation of narcotine with potash would yield trimethylamine, dimethylamine, methylamine, and ammonia in proportions varying with the conditions of the experiment, in which case the nature of the product could afford no trustworthy evidence as to the composition of the material employed.

On the other hand, the existence of narcotine containing three atoms of methyl may, at first sight, seem to render probable the existence of other varieties of the base in which ethyl or a similar radicle takes the place of the whole or part of the methyl. Analogy, however, does not support such an inference. Many natural products are known which contain, in some form or other, methyl as one of their constituents, although corresponding compounds containing ethyl are either entirely unknown or have been obtained only by artificial means. We may mention as examples methyl-salicylic acid, methyl-coniine (von Planta and Kekulé), brucine (Strecker), morphine (Wertheim), codeine (Anderson), caffeine (Wurtz, Rochleder, Strecker), theobromine (Rochleder and Hlasiwetz, Strecker), creatine (Strecker), sarcosine (Strecker, Volhard).

2. According to our analyses, narcotine contains the elements of meconin and cotarnine:—

$$\underset{\text{Narcotine.}}{C_{22}H_{23}NO_7} = \underset{\text{Meconin.}}{C_{10}H_{10}O_4} + \underset{\text{Cotarnine.}}{C_{12}H_{13}NO_3}.$$

After having discussed the probable nature of these two bodies, we shall return to the consideration of their possible functions as constituents of narcotine.

3. We have been unable to find a second reaction altogether analogous to the transformation of opianic acid into meconin and hemipinic acid, regarded as a mere transference of an atom of oxygen from one molecule of opianic acid to another, according to the equation

$$\underset{\text{Opianic acid.}}{C_{10}H_{10}O_5} + \underset{\text{Opianic acid.}}{C_{10}H_{10}O_5} = \underset{\text{Meconin.}}{C_{10}H_{10}O_4} + \underset{\text{Hemipinic acid.}}{C_{10}H_{10}O_6}.$$

Possibly, however, this equation, though correctly expressing the final result, does not represent the actual decomposition which occurs in the first instance. Of course, instead of hemipinic acid, hemipinate of potassium is produced at first, but perhaps also, instead of meconin, a compound of that body with potash, $C_{10}H_{10}O_4$, $KHO(=C_{10}H_{11}KO_5)$, may be the correlative product. The reaction would then be (substituting for potash, in the equation, its equivalent of water)

$$2C_{10}H_{10}O_5 + H_2O = C_{10}H_{12}O_5 + C_{10}H_{10}O_6,$$

strictly analogous to the transformation of oil of bitter almonds into benzylic alcohol and benzoic acid:

$$\underset{\text{Oil of bitter almonds.}}{2C_7H_6O} + H_2O = \underset{\text{Benzylic alcohol.}}{C_7H_8O} + \underset{\text{Benzoic acid.}}{C_7H_6O_2}.$$

According to this supposition, meconin would be an anhydride of a less stable compound $C_{10}H_{12}O_5$, probably a body possessing more or less the characters of a polyatomic alcohol. If, with Berthelot*, we compare meconin to ethylene, opianic acid to aldehyde, and hemipinic acid to acetic acid, the compound $C_{10}H_{12}O_5$ might be compared to alcohol:

---

* Annales de Chimie et de Physique, 3rd series, vol. lvi. p. 77.

Meconin	$C_{10}H_{12}O_4$	C_2H_4	Ethylene.
Hypothetical hydrate of meconin	$C_{10}H_{10}O_5$	C_2H_6O	Alcohol.
Opianic acid	$C_{10}H_{10}O_5$	C_2H_4O	Aldehyde.
Hemipinic acid	$C_{10}H_{10}O_6$	$C_2H_4O_2$	Acetic acid.

The supposed existence of a hydrate of meconin derives some slight support from the fact that, when the product obtained by heating opianic acid with potash is dissolved in water and the solution made acid with hydrochloric acid, the meconin remains for a long time dissolved in the acid liquid unless a great excess of hydrochloric acid is added—apparently as though it did not exist as such in the solution, but required a certain time, or else the aid of a great excess of acid, to enable it to separate from a previous state of combination*.

4. The conversion of opianic acid into meconin by means of nascent hydrogen is a transformation as anomalous as that last considered, if viewed as a direct deoxidation of the acid; but if it be supposed that a compound $C_{10}H_{12}O_5$ is first formed and is converted by subsequent dehydration into meconin, the reaction appears (not as a removal of oxygen, but) as a fixation of hydrogen, and takes its place among a large number of similar transformations which have been observed within the last few years to occur under like conditions:—

$$\underset{\text{Opianic acid.}}{C_{10}H_{10}O_5} + H_2 = \underset{\text{Hydrate of meconin.}}{C_{10}H_{12}O_5}.$$

Among the many analogous reactions we may mention especially the conversion of glucose into mannite, lately effected by LINNEMANN†,

$$\underset{\text{Glucose.}}{C_6H_{12}O_6} + H_2 = \underset{\text{Mannite.}}{C_6H_{14}O_6},$$

—a reaction which perhaps justifies the following comparison of formulæ:—

Meconin	$C_{10}H_{10}O_4$	$C_6H_{12}O_5$	Mannitan.
Hydrate of Meconin	$C_{10}H_{12}O_5$	$C_6H_{14}O_6$	Mannite.
Opianic acid	$C_{10}H_{10}O_5$	$C_6H_{12}O_6$	Glucose.
Hemipinic acid	$C_{10}H_{10}O_6$	$C_6H_{12}O_7$	Mannitic acid.

If this view of the action of nascent hydrogen on opianic acid be adopted, and if the decomposition of that acid by potash be interpreted in the manner suggested in the last paragraph, both reactions may be regarded as giving additional weight to the views of BERTHELOT, who has already pointed out that opianic acid possesses many properties

---

* Among the products which ANDERSON obtained by the action of nitric acid on narcotine, was one which he supposed to be a hydrate of meconin. ANDERSON did not obtain a sufficient quantity of this substance to enable him to ascertain its chemical relations; and we have already shown elsewhere (Proc. Roy. Soc. vol. xi. p. 60) that his analyses agree precisely with the formula of cotarnic acid, $C_{11}H_{12}O_5$: they also agree, though not quite as well, with the composition of a hydrate of meconin $=2(C_{10}H_{10}O_4)H_2O$, but not at all with that of the hydrate whose existence is supposed in the text.

† Annalen der Chemie und Pharmacie, vol. cxxiii. p. 136.

usually considered characteristic of the aldehydes. In any case, however, the fact that nascent hydrogen converts opianic acid into meconin, but has no action on hemipinic acid, excludes the possibility of regarding the first of these bodies as a hemipinate of meconin.

5. The action of hydrochloric and hydriodic acids on opianic acid and its congeners proves that methyl is a constituent of each of them; and since one molecule of hemipinic acid yields two molecules of iodide of methyl when distilled with hydriodic acid, we must assume the existence of two atoms of methyl in each molecule of meconin, opianic acid, or hemipinic acid. It is useless to discuss the function of the methyl in the first two of these substances before possessing more definite knowledge of their chemical nature and of the bodies formed from them when the methyl is eliminated. In the case of hemipinic acid, our knowledge on these points is already sufficient to enable us to form a tolerably clear idea of the state of combination in which its two atoms of methyl may exist.

Hemipinic acid was shown by ANDERSON to be a well-characterized bibasic acid, and to contain, in one molecule, six atoms ($O=16$) of oxygen. Among the better-known acids, one which resembles it in these particulars is tartaric acid, $C_4H_6O_6$. Now the experiments of PERKIN and DUPPA, and of KEKULÉ, as well as those of SCHMITT and DESSAIGNES, clearly show that, although tartaric acid is only bibasic in the strict sense, yet it is tetratomic, or that, in the language of the modern theory of types, it contains four atoms of hydrogen outside the radicle. If we assume the existence of an acid $C_8H_6O_6$ strictly comparable to tartaric acid, that is, containing outside the radicle four atoms of hydrogen whereof two only are replaceable by ordinary processes of saline double decomposition, and if we further suppose the other two atoms to be replaced by methyl, the resulting compound would have the composition of hemipinic acid

$$(C_8H_4(CH_3)_2O_6 = C_{10}H_{10}O_6),$$

and might be expected to resemble it in being a bibasic acid, yielding two molecules of iodide of methyl when boiled with hydriodic acid, but no methylic alcohol when boiled with potash. The two atoms of methyl in such a compound would be combined in the same manner as the one atom of ethyl in ethyl-lactic acid, which, as proved by the experiments of WURTZ and BUTLEROW, cannot be eliminated by the action of alkalis, but, as found by the latter chemist[*], is easily eliminated by the action of hydriodic acid.

If hemipinic acid be allowed to have the constitution here suggested, the decomposition which gives rise to hypogallic acid must be supposed to consist of two stages:—first, the replacement of $(CH_3)_2$ by H_2, resulting in the formation of a hypothetical normal hemipinic acid, $C_8H_6O_6$,

$$C_8H_4(CH_3)_2O_6 + 2HI = C_8H_6O_6 + 2CH_3I;$$

---

[*] On the dissymmetrical constitution of the radicle of lactic acid as the probable cause of the dissimilar functions of its two replaceable hydrogen-atoms, see KEKULÉ, Lehrbuch der Organischen Chemie (Erlangen, 1861), vol. i. pp. 174 and 730. The same considerations apply, *mutatis mutandis*, to the case of a tetratomic acid such as tartaric acid.

secondly, the decomposition of this product, at the temperature of boiling hydriodic acid (125° C.), into carbonic and hypogallic acids:—

$$C_8H_6O_6 = CO_2 + C_7H_6O_4.$$

6. The action of acids on cotarnine proves that one molecule of that substance contains one atom of methyl. When the methyl is eliminated, as by the action of hydrochloric acid, the first phase of the reaction probably consists in the simple replacement of methyl by hydrogen, giving rise to a non-methylized or normal cotarnine,—

$$\underset{\text{Cotarnine.}}{C_{11}H_{10}(CH_3)NO_3} + HCl = \underset{\text{Normal cotarnine.}}{C_{11}H_{11}NO_3} + CH_3Cl;$$

but this compound, in presence of aqueous hydrochloric acid, fixes the elements of water and is converted into cotarnamic acid:—

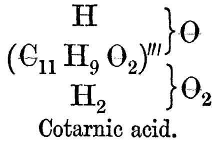
$$\underset{\text{Normal cotarnine.}}{C_{11}H_{11}NO_3} + H_2O = \underset{\text{Cotarnamic acid.}}{C_{11}H_{13}NO_4}.$$

Cotarnic acid, $C_{11}H_{12}O_5$, which may be regarded as the central member of the cotarnine group, is a bibasic acid containing five atoms of oxygen, and is therefore analogous to malic acid, $C_4H_6O_5$. Accordingly, we find, among the derivatives of malic acid, compounds which correspond to all the derivatives of cotarnic acid.

Cotarnic acid	$C_{11}H_{12}O_5$	$C_4H_6O_5$	Malic acid.
Cotarnamic acid . . .	$C_{11}H_{13}NO_4$	$C_4H_7NO_4$	Aspartic acid.
Hydrochlorate of cotarnamic acid	$C_{11}H_{13}NO_4$, HCl	$C_4H_7NO_4$, HCl	Hydrochlorate of aspartic acid.
Cotarnimide (hypothetical normal cotarnine) . .	$C_{11}H_{11}NO_3$	$C_4H_5NO_3$	Malimide.
Methyl-cotarnimide (cotarnine)	$C_{11}H_{10}(CH_3)NO_3$	$C_4H_4(C_6H_5)NO_3$	Phenyl-malimide.

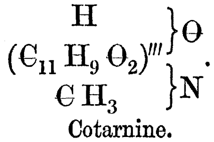
The substance here called *malimide* is produced by the dry distillation of acid malate of ammonium (Pasteur), or of a mixture of equivalent quantities of aspartate of barium and ethyl-sulphate of potassium (Dessaignes): aspartic acid is produced when this compound is boiled with hydrochloric acid (Dessaignes), exactly as we have supposed cotarnamic acid to be formed from cotarnimide.

The close analogy existing between the derivatives of cotarnic acid and those of malic acid indicates that cotarnic acid is probably triatomic; hence the typical formulæ by which we represented this acid and cotarnine in our preliminary communication*, require to be somewhat modified, and would probably be more correctly written thus:—



$$\left.\begin{array}{l} H \\ (C_{11}H_9O_2)''' \end{array}\right\} O \quad \left.\begin{array}{l} \\ H_2 \end{array}\right\} O_2$$

Cotarnic acid.



$$\left.\begin{array}{l} H \\ (C_{11}H_9O_2)''' \end{array}\right\} O \quad \left.\begin{array}{l} \\ CH_3 \end{array}\right\} N.$$

Cotarnine.

---

* Proceedings of the Royal Society, vol. xi. p. 60.

This formula for cotarnine, which represents it as derived from the double type $\left.\begin{matrix} H_2\Theta \\ H_3N \end{matrix}\right\}$, is still in accordance with the experiments of How* (who found it impossible to replace hydrogen in cotarnine by means of iodide of methyl), for it will be seen that the whole of the hydrogen of the ammonia is represented as already replaced.

7. Meconin being regarded as a polyatomic anhydride, and cotarnine as an imide, it is allowable to suppose that the constitution of narcotine may be similar in some degree to that of the oxygenated alkaloids obtained by WURTZ by the union of oxide of ethylene with ammonia.

Meconin digested with aqueous ammonia in a sealed tube forms a solution from which it is not deposited on cooling, nor even when the excess of ammonia is expelled by cautious evaporation. Possibly the investigation of the compound thus formed may throw further light on the constitution of narcotine.

---

* Transactions of the Royal Society of Edinburgh, vol. xxi. p. 31.