[CONTRIBUTION FROM THE RESEARCH LABORATORY, DOMINION RUBBER CO., LTD., GUELPH, ONTARIO]

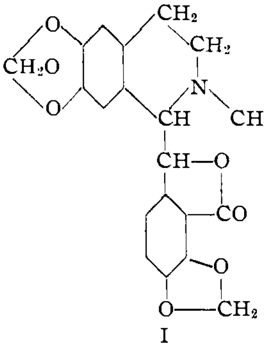
The Alkaloids of Fumariaceous Plants. XLIV. *Corydalis incisa* (Thunb.) Pers. and the Constitutions of Adlumidine and Capnoidine

BY RICHARD H. F. MANSKE

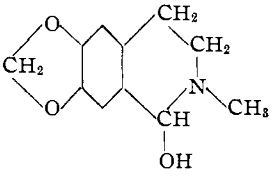
Corydalis incisa (Thunb.) Pers. is native to the Chinese provinces of Fukien, Kiangsi, Kiangsu, and Chekiang as well as to the Liu-Kiu Islands of Japan. It has been placed in Section *Eucorydalis* Prandtl, Subsection *Eucapnoides* Fedde along with *C. aurea* Willd. and *C. sempervirens* (L.) Pers. It is obvious, however, that the contained alkaloids do not permit the relegation of the latter two species to the same narrow group.[1] Similarly *C. incisa* has been found to contain alkaloids—protopine, adlumidine, *l*-corypalmine, and F62 ($C_{19}H_{17}O_5N$?)—which indicate a close relation to *C. sempervirens* and *C. micrantha* (Engelm.) Gray, a group of plants taxonomically close to the *C. aurea* group but lacking the preponderance of the protoberberines.

Adlumidine was first found in *Adlumia fungosa* (Ait.) Greene[2] and subsequently in *C. thalictrifolia* Franch.[3]

It was regarded as isomeric with capnoidine[1,4,5] and both alkaloids were represented by $C_{19}H_{15}O_6N$, a formula which is now altered to $C_{20}H_{17}O_6N$, partly on the basis of new analytical data, but unequivocally because both alkaloids have been shown to have the same structure as bicuculline[6] (I). This determination of structure was readily achieved by hydrolytic oxidation with dilute nitric acid,[6] the two fragments, hydrastinine (II), and 2-carboxy-3,4-methylenedioxybenzaldehyde (III) being compared with the same fragments obtained from bicuculline.



I



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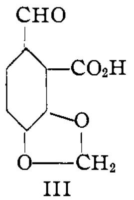

III

It may be pointed out that adlumidine and capnoidine are optical antipodes. The former has $[\alpha]^{25}\mathrm{D}$ + 116.2° ($C = 2$ in chloroform) and the latter has $[\alpha]^{22}\mathrm{D}$ − 113.2° ($C = 0.8$ in chloroform). An earlier value (−56.6°) was in error by a factor of two. The *dl*-form was easily prepared as an apparent chemical individual by recrystallizing equal weights of the two alkaloids and melted sharply at 205°.

Experimental

Isolation of the Alkaloids.—The plant material was grown in a garden at Ottawa, Canada, and collected largely at the late flowering stage. There was available a total of only 1800 g. of dried material which was treated by the procedure frequently described.[2]

Protopine.—The non-phenolic fraction BS crystallized with great facility in contact with hot methanol and yielded 1.6 g. of protopine which when recrystallized from chloroform–methanol melted sharply at 210°[7] either alone or in admixture with authentic protopine.

Adlumidine.—The filtrate from the crystallization of the protopine was rendered just acid by the addition of dilute acetic acid and boiled to expel the methanol. The addition of sodium nitrate caused the separation of most of the remaining protopine as sparingly soluble nitrate. The filtrate from this was basified with ammonia and extracted with a large volume of ether. The resinous residue from the ether extract crystallized readily in contact with methanol and when the separated crystals were recrystallized from chloroform–methanol the base then melted at 236–237°. In admixture with a specimen of adlumidine it also melted at 236–237°. The yield was *ca.* 80 mg.

***l*-Corypalmine.**—The combined fractions BCE and EEC were dissolved in chloroform–methanol and the filtered solution evaporated to a small volume. The sparingly soluble crystals which separated were again recrystallized from the same solvent mixture and then melted at 230° either alone or in admixture with a specimen of *l*-corypalmine from *Dicentra oregana*.[8] *Anal.* Calcd. for $C_{20}H_{23}O_4N$: C, 70.38; H, 6.75; N, 4.10; OCH_3, 27.27. Found: C, 70.32; H, 6.71; N, 4.32; OCH_3, 25.83; $[\alpha]^{27}\mathrm{D}$ −274° ($C = 0.2$ in chloroform). The yield was approximately 0.3 g.

Alkaloid F62.—The fraction BC crystallized from methanol with some difficulty the base tending to separate as an oil. After repeated warming and slow cooling the base had largely crystallized. A recrystallization from chloroform–methanol yielded colorless well developed stout hexagonal prisms which melted at 196°. It could not be identified with any alkaloid in the author's possession. *Anal.* Calcd. for $C_{19}H_{17}O_5N$: C, 67.26; H, 5.01; N, 4.16. Found: C, 67.06, 67.00; H, 5.19, 5.10; N, 4.13, 4.16; OCH_3, negative. It should be pointed out that the quantity of available plant material was too small to permit a thorough examination of the mother liquors. The fractions BSE and EES in contact with methanol yielded several large well formed crystals inadequate for analysis and of uncertain melting point.

Oxidation of Adlumidine and of Capnoidine.—The oxidations were carried out in separate experiments with each base and the results were exactly the same in both cases.

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(1) Manske, *Can. J. Research*, **B17**, 57 (1939).

(2) Manske, *ibid.*, **8**, 210 (1933).

(3) Manske, *ibid.*, **21B**, 111 (1943).

(4) Manske, *ibid.*, **8**, 407 (1933).

(5) Manske, *ibid.*, **B14**, 347 (1936).

(6) Manske, *ibid.*, **8**, 142 (1933).

(7) All melting points are corrected.

(8) Manske, *Can. J. Research*, **10**, 765 (1934).

A solution of 0.5 g. of the alkaloid in 5 cc. of dilute nitric acid (2 cc. concd. nitric acid diluted to 10 cc. with water) was heated for twenty minutes on the steam-bath. The cooled solution was treated with pellets of sodium hydroxide while cooling until alkaline when hydrastinine separated in colorless crystals. When this was recrystallized from ether the hydrate of hydrastinine was obtained melting at 115–115°. This and all of the following derivatives were compared with authentic specimens by mixed melting point determinations. The hydrastinine was converted into a mixture of oxyhydrastine (m. p. 96–97°) and hydrohydrastinine (picrate, m. p. 178°) by heating with alcoholic potash on the steam-bath for five hours.[6]

The alkaline filtrate from which the hydrastinine had separated was acidified with hydrochloric acid and exhausted with ether. The combined ether extract was evaporated to a small volume and heated with an excess of sodium hydroxide on the steam-bath overnight, a few granules of aluminum being added to convert the nitrate to ammonia. The acidified solution was again extracted with ether and the residue from the ether washed with cold water to remove the 3,4-methylenedioxyphthalic acid. (This was recovered from the aqueous solution, sublimed *in vacuo*, and the resulting anhydride recrystallized from acetone–ether, m. p. 136°.) The water insoluble portion was recrystallized first from boiling water and then from very dilute ethanol and obtained in colorless plates melting sharply at 232° (3,4-methylenedioxyphthalide).

***dl*-Adlumidine or Capnoidine.**—A mixture of 0.1 g. of each of adlumidine and of capnoidine was dissolved in boiling chloroform. The solvent was largely evaporated and the resinous residue treated with *ca.* 5 cc. of hot methanol and momentarily heated to yield a homogeneous solution. Almost immediately the *dl*-base separated in stout prisms which melted sharply at 205°. One recrystallization from chloroform–methanol did not alter the melting point.

Summary

Corydalis incisa (Thunb.) Pers. has yielded three known alkaloids (protopine, adlumidine, and *l*-corypalmine) as well as one (F62) which has not been identified. The structures of adlumidine and of capnoidine have been determined as the same as that of bicuculline. They are optical antipodes and on admixture yield a racemic compound.

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Amylose Complexes

BY WALTER J. KATZBECK AND RALPH W. KERR

Rundle and co-workers,[1–9] Bear,[10] and others, have developed the theory that when complexes are formed between amylose and agents such as iodine, alcohols and fatty acids, the long, linear starch molecules form helices around the complexing agents. X-Ray diffraction patterns of these powdered complexes were best explained in all cases by a crystalline structure consisting of closely packed helices. Since the complexing agent can be removed from or introduced into the crystalline structure without materially altering the diagram, it was believed that the complexing agent is placed in the holes in the crystal structure. At least in the case of the fatty acid complexes and possibly also the iodine complex, the amount of complexing agent held by the crystal structure can be explained satisfactorily with reference to the amount of space within the helices, in contrast to the insufficient amount of intersticial space between helices. These workers have pointed out, furthermore, that all of these complexing agents have one obvious property in common: possession of a permanent electric moment, or, in the case of iodine, a tendency to assume an induced moment. They have proposed that the stability of the complex is the result of dipolar action.

Although this explanation appears to be satisfying and is entirely consistent with all the facts observed, one of these experimental approaches which has been used in the past to develop this hypothesis has of necessity been limited, and this limitation, among others, has given rise to alternate explanations from time to time to account for complex formation by amylose. The alternate explanation most commonly advanced in the past has been that complex formation is an adsorption phenomenon between the agent and the hydrophilic groups along the amylose chain.[11–18]

One experimental approach to the problem used by Rundle and co-workers has been to compare the relatively large amounts of iodine and fatty acids taken up by "V" form amylose in the solid state with insignificant amounts taken up by other solid forms of amylose which give "A" or "B" type, X-ray diffraction patterns. The "A" and "B" forms of amylose are exemplified by the retrograded (spontaneously crystallized) and

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(1) R. E. Rundle and D. French, THIS JOURNAL, **65**, 558 (1943).

(2) R. E. Rundle and D. French, *ibid.*, **65**, 1707 (1943).

(3) R. E. Rundle and F. C. Edwards, *ibid.*, **65**, 2200 (1943).

(4) R. E. Rundle and R. R. Baldwin, *ibid.*, **65**, 554 (1943).

(5) F. Bates, D. French and R. E. Rundle, *ibid.*, **65**, 142 (1943).

(6) R. E. Rundle, J. F. Foster and R. R. Baldwin, *ibid.*, **66**, 111 (1944).

(7) R. R. Baldwin, R. S. Bear and R. E. Rundle, *ibid.*, **66**, 2116 (1944).

(8) F. F. Mikus, R. M. Hixon and R. E. Rundle, *ibid.*, **68**, 1115 (1946).

(9) R. S. Stein and R. E. Rundle, *J. Chem. Physics*, **16**, 195 (1947).

(10) R. S. Bear, THIS JOURNAL, **66**, 2122 (1944).

(11) C. S. Hanes, *New Phytologist*, **34**, 101 and 189 (1937).

(12) C. S. Hanes and M. Cattle, *Proc. Roy. Soc.* (*London*), **125B**, 387 and 414 (1939).

(13) L. Lehrman, THIS JOURNAL, **64**, 2144 (1942).

(14) T. J. Schoch, *ibid.*, **64**, 2954 (1942).

(15) T. J. Schoch and C. B. Williams, *ibid.*, **66**, 1232 (1944).

(16) R. Whistler and G. E. Hilbert, *ibid.*, **66**, 1721 (1944).

(17) T. J. Schoch, *Advances in Carbohydrate Chem.*, **1**, 247 (1945).

(18) T. J. Schoch, *Bakers' Digest*, **21**, No. 1, 1 (1947).