the crystallizations. Whereas during earlier crystallizations the product melted at 140–142°, the purest isomer C (fine needles, different in appearance from those of isomer A) from the final crystallization melted sharply at 135–136°. *Anal.* Calcd. for $C_{11}H_{16}O_8$ (isomer C): C, 47.83; H, 5.80. Found: C, 47.84; H, 5.81.

The mother liquors from the original crystallization gave, on concentration *in vacuo*, a second crop of crystals (0.58 g., m.p. 112–115°). Repeated recrystallization of these from ether–pentane (2:1) gave a minute amount of needles of isomer A (infrared spectral identity established).

Optical Rotation Behavior of Isomers A, B and C in Solutions.—A.C.S. reagent grade chloroform or pyridine was used. Rotations were made in a half-decimeter polarimeter tube. All solutions were left standing at room temperature for the periods stated.

Chloroform Solutions.—Isomer A: For a solution with *c* 1.015, an initial value of $[\alpha]^{25}D$ +108.4° had not changed in 46.5 hours. A solution with *c* 1.06 gave, after standing *ca.* 14 days, a final $[\alpha]^{25}D$ +115.4°. In each case, the product, after expelling the $CHCl_3$ *in vacuo* and crystallizing the residue from ether–pentane, gave an infrared spectrum identical with that of unchanged isomer A.

Isomer B: A solution with *c* 1.05 showed an initial $[\alpha]^{25}D$ +46.1° and after 28.5 hours a final $[\alpha]^{25}D$ +30.5°. The infrared spectrum of the product, crystallized from ether–pentane, showed significant differences from that of isomer B, but did not reveal conclusive evidence of the appearance of absorption bands characteristic of isomer C. A solution with *c* 1.00 showed a final $[\alpha]^{25}D$ +38.6° after *ca.* 14 days and an infrared spectrum of the product was identical with that from the product of a similar mutarotation study of isomer C.

Isomer C: A solution with *c* 1.00 showed an initial $[\alpha]^{25}D$ −20.0° which changed in *ca.* 22 hours to a value of $[\alpha]^{25}D$ +6.6°. An infrared spectrum of the product, crystallized from ether–pentane, showed enhancement of intensity of the peaks at 760 and 3328 cm.$^{-1}$ characteristic of isomer B. A solution with *c* 1.005 showed a final $[\alpha]^{25}D$ +32.8° after *ca.* 14 days and an infrared spectrum of the product was identical with that from the product of a similar mutarotation study of isomer B.

5:1 Pyridine–Water Solutions.—Isomer A: A solution with *c* 1.04 showed an initial $[\alpha]^{25}D$ +115.4° and after *ca.* 3 days an $[\alpha]^{25}D$ +55.8°, which did not change on further standing. An infrared spectrum of the product, crystallized from ether–pentane, was identical with that of isomer B.

Isomer B: A solution with *c* 1.0125 showed an initial $[\alpha]^{25}D$ +50.4° and after *ca.* 4.25 days an $[\alpha]^{25}D$ +51.4°. An infrared spectrum of the product, crystallized from ether–pentane, showed unchanged isomer B.

Isomer C: A solution with *c* 1.0125 showed an $[\alpha]^{25}D$ +46.4° 15 minutes after dissolution of the compound. The rotation values observed 4 hours thereafter and after a total period of *ca.* 4.25 days were $[\alpha]^{25}D$ +54.3 and +59.8°, respectively. An infrared spectrum of the product (from the solution kept 4.25 days), crystallized from ether–pentane, appeared to be identical with that from isomer B.

Quantitative Comparison of the Infrared Absorption in the Carbonyl Region by Isomers A, B, C and Tetra-*O*-acetyl-β-D-xylopyranose.—Freshly dried chloroform was used for making the solutions. An NaCl cell of thickness l = 0.0502 cm. was used. The spectrophotometer slit width was constant at 46 μ during the measurements. The results of the measurements at the different comparable concentrations are summed up in Table II.

TABLE II

Compound	ν_{max}, cm.$^{-1}$	Concn., c, mole/liter	$E^{(a)}_{max} \times cl$ (= $\log_{10} (T_0/T)_{max}$)	$\Delta\nu^{(a)}_{1/2}$ cm.$^{-1}$	Apparent integrated absorption intensity $A (\times 10^{-4})$, mole^{-1} l. cm.$^{-2}$
		0.018170	0.710	46.0	12.54
Isomer A	1745	.009085	.370	40.0	11.36
		.004543	.188	40.0	11.54
		.018840	.790	42.0	12.27
Isomer B	1747	.009421	.423	37.0	11.58
		.004711	.210	34.0	10.57
		.018190	.795	40.0	12.19
Isomer C	1745	.009095	.421	35.0	11.30
		.004548	.202	31.0	9.60
		.015720	.900	46.5	18.50
Tetraacetyl-	1752	.007860	.456	40.0	16.18
xylose		.003930	.220	36.0	14.05

Acknowledgments.—The author wishes to thank Dr. R. N. Jones for advice received in making the quantitative infrared studies and for making available information from the manuscript of reference 10 while still in press. Deep gratitude is expressed to Dr. R. W. Watson for the keen interest shown in this work and to Dr. C. T. Bishop for useful suggestions and criticism received. The technical assistance of Mr. F. Rollin in making the infrared spectrograms is gratefully acknowledged.

OTTAWA 2, CANADA

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, IOWA STATE COLLEGE]

Studies on the Schardinger Dextrins. X. The Interaction of Cyclohexaamylose, Iodine and Iodide. Part I. Spectrophotometric Studies[1]

BY JOHN A. THOMA[2] AND DEXTER FRENCH[3]

RECEIVED JUNE 23, 1958

The cyclohexaamylose, I_2, I^- system was studied as a model for the starch, I_2, I^- system. Using the method of continuous variation it was found that α-dextrin in aqueous I_2 forms an αI_2 complex in the absence of I^- and an αI_3^- complex in the presence of I^-. The method of continuous variation has been extended to some special ternary systems.

Introduction

The Schardinger dextrins, and particularly cyclohexaamylose (referred to hereafter as α), have been of very considerable interest because of their ability to form highly colored, crystalline iodine complexes resembling the starch–iodine complex.[4] The unique molecular structure of α (cyclic molecule consisting of six α-1 → 4-linked D-glucopyranose units) makes it possible to form inclusion compound *in solution* as well as in the solid state. Thus systems containing α and complexing agents are particularly favorable for study as models of the far more complicated starch systems.

Although the understanding of the starch–iodine reaction has advanced substantially in recent years, several aspects remain controversial. Some con-

---

(1) This work was supported in part by grants from Union Carbide and Carbon Corporation and General Foods Corporation.

(2) Union Carbide and Carbon Fellow 1957–1958.

(3) To whom inquiries concerning this article should be made.

(4) D. French, *Adv. Carbohydrate Chem.*, **12**, 189 (1957).

temporary workers[5–7] have reported that when I^- is added to starch–iodine solutions, it plays an integral part in the reaction but it remains uncertain whether or not starch can form an iodide-free iodine complex.[8] It was thought that this question could be resolved readily by examining the absorption spectra of starch and dextrin solutions in aqueous I_2 in the presence and absence of I^- because complexes of I_2 and those involving both I_2 and I^- should show characteristic spectra. To repress any I^- which might arise from the hydrolysis of I_2, either HIO_3 or strong acids can be added. Equations (1) and (2) represent the reactions involved

$$I_2 + H_2O = H^+ + I^- + HIO \qquad (1)$$

$$IO_3^- + 5I^- + 6H^+ = 3H_2O + 3I_2 \qquad (2)$$

Rundle and French[9] have demonstrated the formation of a starch–iodine complex by absorption of I_2 vapors by helical amylose in the solid state. Since no iodide was added, it was inferred that I^- was not necessary for the reaction. However, even with "dry" amylose, it now appears likely that I^- was produced either by the reduction of I_2 by impurities or by solvolysis of I_2 by occluded H_2O or alcohol, or the OH groups of the carbohydrate.

Our preliminary investigations of the absorption spectra of α–I_2–I^- solutions and the formation of αI_2 and αKI crystals[4] suggested that the dextrin, I_2 and I^- reactions involve three binary systems (αI_2, αI^- and I_3^-[10]) and one ternary system (αI_3^-). The extent of dissociation of the α–I_2–I^- complex appeared to be very small, indicating that the determination of the stoichiometry of the complex would be amenable to the method of continuous variation.

Theory

Applications of the method of continuous variation and the implications and validity of the assumptions made in the theory of this method have been critically reviewed by Woldbye.[11] Vosburgh[12] and Katzin[13] have extended the method to binary systems in which successive dissociation constants for the complex differ by several orders of magnitude. In this paper, we extend the method of continuous variation to some special ternary systems which may occur when α or starch and I_2 and I^- react. The most general case which is treated involves the competition of one binary system with a ternary system and is represented

$$A + B = AB \qquad (3)$$

$$aA + bB + cC = A_aB_bC_c \qquad (4)$$

where a/b and c/b are, respectively, the ratios of A:B and C:B in the ternary complex. To determine c/b experimentally, the absorbancy (or some other property) of the ternary complex is measured in a set of solutions containing an amount x of B and an amount $C_0 - x$ of C. Each solution also contains a fixed amount of A in large excess over that required for complex formation. When the absorbancy due to the ternary complex is plotted against x, the value of c/b is given by $X_{\max}/(C_0 - X_{\max})$. After the ternary system has reached equilibrium the equations may be written

$$A = A_0 - \text{complex} \approx A_0 \qquad (5)$$

$$B = x - p - q \qquad (6)$$

$$C = C_0 - x - cq \qquad (7)$$

$$K' = AB/p \qquad (8)$$

$$K'' = A^aB^bC^c/q \qquad (9)$$

where A, B, C, p and q represent, respectively, the equilibrium concentrations of A, B, C, binary complex and ternary complex, and K' and K'' are the dissociation constants for the binary and ternary complexes.

Substituting 5, 6, 7 and 8 into 9, differentiating with respect to x, and setting $dq/dx = 0$, the condition for a maximum, one obtains after simplification $c/b = X_{\max}/(C_0 - X_{\max})$.

Similarly, when A and C are continuously varied in the presence of a large excess of B, the combining ratio of A and C in the complex may be evaluated.

However, when A and B are continuously varied in a large excess of C their apparent ratio will vary between a/b and 1 depending upon the magnitudes of the dissociation constants of the binary and ternary complex and the amount of C in the system. Only if $a/b = 1$ or the amount of binary complex formed is insignificant may the ratios of any two reactants in the ternary complex be found by continuously varying them in the presence of a large excess of the third component. Similarly, if $K'' >> K'$ and the ternary reaction is the preponderating equilibrium, the combining ratio of any two components in the complex may be found by continuously varying these components in the presence of an added constant amount of the third (not necessarily a large excess).

Even though equilibrium constants may be unfavorable, it is sometimes possible to choose conditions under which the method of continuous variation is applicable to ternary systems. The α–I_2–I^- system will serve as an example, and may be represented by the series of equations

$$I_2 + I^- = I_3^-;\ K_I = [I_2][I^-]/[I_3^-] \qquad (10)$$

$$I_2 + \alpha = \alpha I_2;\ K_1 = [\alpha][I_2]/[\alpha I_2] \qquad (11)$$

$$\alpha I_2 + I^- = \alpha I_3^-;\ K_2 = [\alpha I_2][I^-]/[\alpha I_3^-] \qquad (12)$$

$$\alpha + I^- = \alpha I^-;\ K_3 = [\alpha][I^-]/[\alpha I^-] \qquad (13)$$

$$\alpha I^- + I_2 = \alpha I_3^-;\ K_4 = [\alpha I^-][I_2]/[\alpha I_3^-] \qquad (14)$$

$$\alpha + I_2 + I^- = \alpha I_3^-;\ K_5 = [\alpha][I_2][I^-]/[\alpha I_3^-] \qquad (15)$$

let concentration α added = $[\alpha_t]$
and concentration I_2 added = $[I_{2t}]$
and concentration I^- added = $[C_0 - I_{2t}]$

then at equilibrium if conditions are chosen such that $[\alpha]$ remains essentially constant as $[I_2]$ and $[I^-]$ are varied (a condition which can be achieved by adding a large excess of α or by choosing conditions such that the degree of formation of the complex is small) then at equilibrium these equa-

---

(5) G. A. Gilbert, J. V. R. Marriot, *Trans. Faraday Soc.*, **44**, 84 (1948).

(6) R. J. Higginbotham, *J. Textile Inst.*, **40**, t783 (1949).

(7) D. L. Mould, *Biochem. J.*, **58**, 593 (1954).

(8) E. O. Forster, Ph.D. Thesis, Columbia University, 1951, reported that α and amylose could form I_2 complexes in the absence of I^-. These tests were conducted at *p*H 6 in 0.2 *M* KIO_3, conditions which do not effectively prevent the formation of I^- by the hydrolysis of I_2. The appearance of Forster's absorption spectra indicates that his complexes contained I^-.

(9) R. E. Rundle and D. French, THIS JOURNAL, **65**, 1696 (1943).

(10) G. Jones and B. B. Kaplan, *ibid.*, **50**, 1845 (1928).

(11) F. Woldbye, *Acta Chem. Scand.*, **9**, 299 (1955).

(12) W. C. Vosburgh and G. R. Cooper, THIS JOURNAL, **63**, 437 (1941).

(13) L. I. Katzin and E. J. Gebert, *ibid.*, **72**, 5455 (1950).

tions may be written where brackets represent concentrations

$$[I_2] = [I_{2t}] - [I_3^-] - [\alpha I_2] - [\alpha I_3^-] \quad (16)$$

and

$$[I^-] = [C_0 - I_{2t}] - [I_3^-] - [\alpha I^-] - [\alpha I_3^-] \quad (17)$$

and

$$[\alpha] \approx [\alpha_t] \quad (18)$$

Now substituting 16, 17 and 18 into 11 and 13 we obtain

$$[\alpha I_2]\{K_1 + [\alpha_t]\} = [\alpha I_2](k_1) = [\alpha_t]([I_2] - [I_3^-] - [\alpha I_3^-]) \quad (19)$$

and

$$[\alpha I^-]\{K + [\alpha_t]\} = [\alpha I^-](k_3) = [\alpha_t]\{[C_0 - I_{2t}] - [I_3^-] - [\alpha I_3^-]\} \quad (20)$$

but from 10 and 15

$$[I_3^-] = K_5[\alpha I_3^-]/K_1[\alpha] = k_5[\alpha I_3^-] \quad (21)$$

Then substituting 21 into 19 and 20 we obtain

$$[\alpha I_2] = ([\alpha_t]/k_1)\{[I_{2t}] - [\alpha I_3^-](1 + k_5)\} \quad (22)$$

and

$$[\alpha I^-] = ([\alpha_t]/k_3)\{[C_0 - I_{2t}] - [\alpha I_3^-](1 + k_5)\} \quad (23)$$

Now substituting 16, 17 and 18 into 15 and substituting 21, 22 and 23 into the resulting equation we obtain after simplification and combining constants

$$(K_5)[\alpha I_3^-] = \{k'[I_{2t}] - k''[\alpha I_3^-]\}\{k'[C_0 - I_{2t}] - k''[\alpha I_3^-]\} \quad (24)$$

then differentiating with respect to I_{2t} and setting $d[\alpha I_3^-]/dI_{2t} = 0$, the condition for a maximum, we obtain after simplification: $I_{2t\,\max} = C_0/2$.

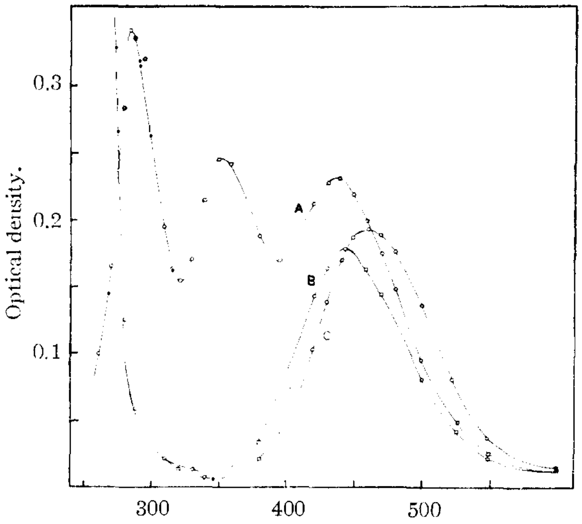


Fig. 1.—Ultraviolet and visible absorption of α–I_2 and I_2 systems in the presence of HIO_3 and the α–I_2 system in the absence of HIO_3: A, 2.6 × 10^{-4} M I_2, 4.8 × 10^{-3} M α; B, 2.6 × 10^{-4} M I_2, 4.8 × 10^{-3} M α, 0.08 M HIO_3; C, 2.6 × 10^{-4} M I_2 in 0.08 M HIO_3. Distilled water was used for the blank.

By similar considerations, it can be shown that if I_2 and α are continuously varied in the presence of a constant amount of I^- the method of continuous variation would show a maximum where the ratio of I_2 to α equals one.

The α–I_2–I^- system has been shown to be in rapid reversible equilibrium by potentiometric methods; these results will be reported in another paper.

Experimental

Materials.—The preparation of pure α has been described elsewhere.[4] All other reagents were of the purest grade commercially available and used without further purification. The absence of the blue starch–iodine complex when a saturated solution of I_2 in 0.2 M HIO_3 was added to an equal volume of 0.5% soluble starch indicated that the I^- concentration was insignificant.[14] The purity of stock α was determined by measuring its optical rotation.[4]

Apparatus.—For the spectral studies, a Beckman model DU spectrophotometer was used with 1.00-cm. silica cells. Optical rotation was determined in a Rudolph precision polarimeter.

Procedure.—A nearly saturated solution of stock I_2 was made by shaking or stirring I_2 crystals in water for two days at room temperature. The concentration of this solution was determined immediately before use by measuring its optical density[15] when diluted 1 to 5 at 460 mμ. Standard solutions of I_2 were then made by appropriate dilution of the stock solution. Standard α and KI solutions were made by appropriate dilution of exactly weighed amounts of these reagents. During the course of experiments, it was frequently necessary to prepare standard I_2 solutions because exposure to air resulted in volatilization. All optical density measurements were made at room temperature in capped silica cells. The procedure employed for continuous variation studies has been described elsewhere.[12,13]

Results and Discussions

Binary Systems.—Curves B and C in Fig. 1 depict, respectively, the absorption spectra of I_2 in 0.08 M HIO_3 in the presence and absence of excess α (*vs.* distilled water blank). The shift of the I_2 maximum upon addition of α suggests the formation of an α–I_2 complex. When the method of continuous variation was applied to the α-I_2 system and the data plotted in Fig. 2, it appears that I_2 and α react in a 1:1 ratio. In this study,

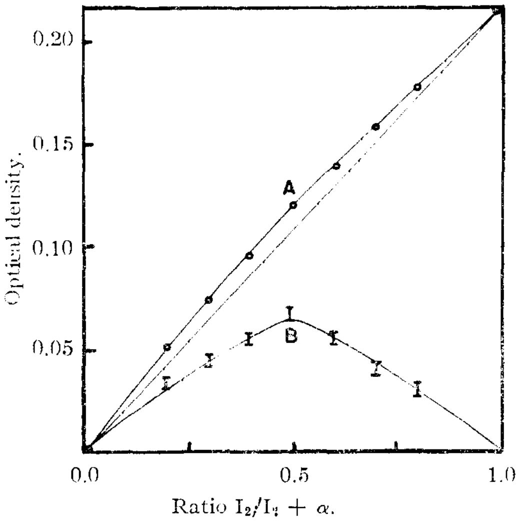


Fig. 2.—Continuous variation plot for the α–I_2 system in 0.2 M HIO_3: A, observed optical density at 420 mμ as I_2 was varied from 0 to 4.57 × 10^{-4} M; B, five times difference between the optical density of A and same solution minus α; 0.2 M, HIO_3 served as a blank.

---

[14] Under the conditions which Forster used (see ref. 8), a deep blue complex was formed which was only slowly destroyed upon strong acidification.

[15] A. D. Awtrey and R. E. Connick, THIS JOURNAL, **73**, 1842 (1951).

hydrolysis of I_2 was repressed by 0.2 M HIO_3 which served as a blank. Below 5×10^{-4} M I_2, Beer's law was obeyed at all wave lengths tested (420, 460, 480 mμ).

No spectral evidence was obtained supporting the formation of an α–I^- complex even though solutions containing as much as 2.0% α were studied. Failure to note any spectral shifts may be attributed to a large dissociation constant and/or a close similarity of the I^- and α–I^- spectra.

Ternary System.—When α and I_2 were allowed to react in the absence of HIO_3 (Fig. 1 curve A), two new maxima were observed at 290 and 353 mμ. The similarity of curve A to the I_3^- spectrum[15] suggested that a complex of α with I_3^- might be responsible for these new peaks. The peak at 420 mμ was attributed to the αI_2 complex. To test the hypothesis that an α–I_3^- complex was formed, the spectrum of a solution containing 1.1×10^{-5} M I_2, 2.5×10^{-5} M I^- and 1.2×10^{-3} M α was compared to the spectrum of a solution containing the same amount of I_2, but 800 times the amount of I^-. The spectra of these solutions are essentially identical (Fig. 3). The possibility that the spectrum of the α–I_2–I^- solution resulted from free I_3^- was dismissed because at this dilution, without added α, the calculated[14] optical density at 288 mμ would be only 0.006, compared to the observed optical density of 0.410.

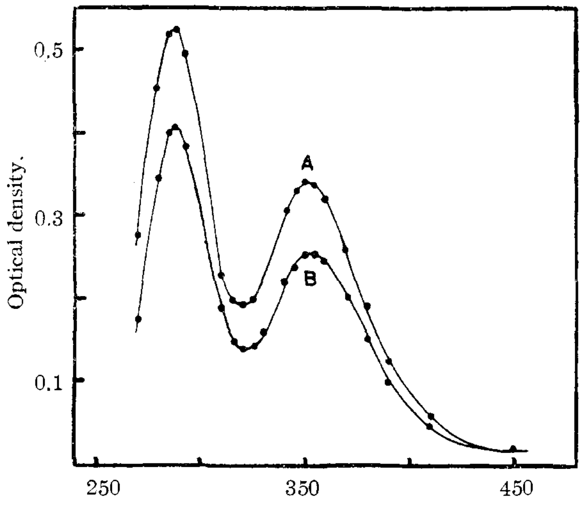


Fig. 3.—Ultraviolet and visible absorption spectra of I_3^- and αI_3^-: A, 1.1×10^{-5} M I_2, 2.0×10^{-2} M I^-; B, 1.1×10^{-5} M I_2, 2.5×10^{-5} M I^-, 1.2×10^{-3} M α. Distilled water was used for a blank.

When I_2 and α were continuously varied in the presence of I^- and the optical densities plotted against the ratio $I_2/(I_2+\alpha)$ (Fig. 4), it was apparent that I_2 and α react in the ternary complex in a 1:1 ratio. Similarly when the optical densities of solutions continuously varied in I_2 and I^- in constant α were plotted against the ratio $I^-/I_2 + I^-$ (Fig. 5), it was apparent that I_2 and I^- reacted in a 1:1 ratio in the complex. These data supported the inference arrived at from the shape of the absorption spectrum that the complex had the formula αI_2^-. Perchloric acid (0.8 M) was added to all solutions in this group to suppress the hydrolysis of I_2 according to equation 1.

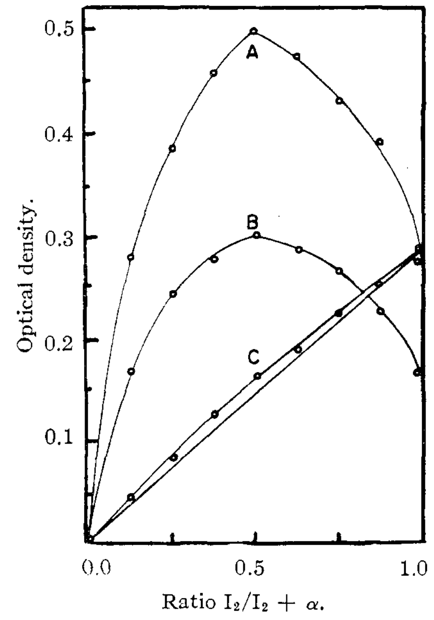


Fig. 4.—Continuous variation plot of the α–I_2–I^- system in 2.5×10^{-5} M I^- in 0.8 M $HClO_4$: A, observed optical density as I_2 was varied from 0 to 4×10^{-4} M at 288 mμ; B, 350 mμ; C, 440 mμ.

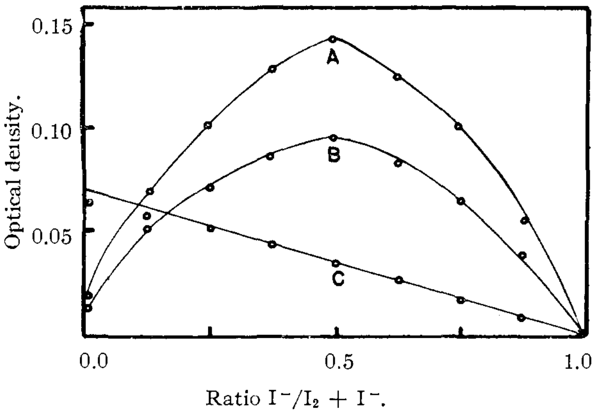


Fig. 5.—Continuous variation plot of the α–I_2–I^- system in 1.3×10^{-4} M α and 0.8 M $HClO_4$: A, observed optical density as I^- was varied from 0 to 1.0×10^{-4} M at 288 mμ; B, 350 mμ; C, 440 mμ. 0.8 M $HClO_4$ served as a blank.

When α was varied between 10^{-3} and 10^{-5} M and I_2 and I^- were varied over as large a range as was suitable for spectrophotometric measurement, all the maxima (other than that of I_2) in the region of 350 to 650 mμ could be attributed to I_3^-, αI_3^- or αI_2.

Because it has been shown that α can form an I_2 complex in the absence of I^- and because α serves as a simple model for the amylose helix, it will be of interest to examine the spectra of amylose–I_2 solutions in the absence of I^- to see if amylose and I_2 complex.

From the results of this study, it may be inferred that the absorption spectra of starch–iodine complexes will vary greatly depending on the ratio of iodine to iodide in the complex; moreover, it may be possible to determine this ratio quite unambiguously by the method of continuous variations, if a system can be found in which equilibrium exists.

AMES, IOWA

COMMUNICATIONS TO THE EDITOR

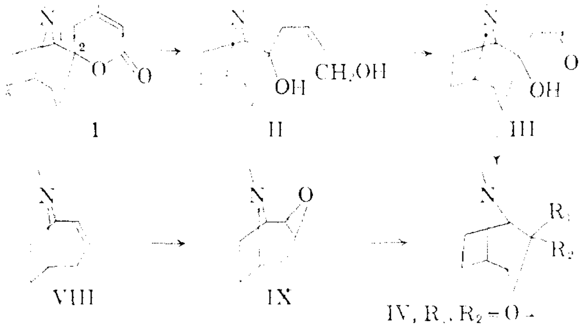
THE STRUCTURE OF DIOSCORINE

Sir:

Dioscorine, $C_{13}H_{19}O_2N$, a water-soluble alkaloid, has been isolated from *Dioscorea hirsuta* Blume[1,2] and *Dioscorea hispida* Dennst.[3,4] The early structural investigations[2] were continued by Pinder[3-9] who has proposed three structures, including I, for dioscorine. No facts have been presented from which the structure of the nitrogenous nucleus and the location of the lactone ring present in the alkaloid could be deduced conclusively. In this communication we wish to present findings which establish structure I for dioscorine.

Reduction of the alkaloid with lithium aluminum hydride gave a diol (II), m.p. 121° (picrate, m.p. 164–165°, lit.[8] 159–160°), which by ozonization was converted to glycolaldehyde and a hydroxyketone (III), m.p. 25°, infrared peaks at 3540 cm.$^{-1}$ (OH); 1705 cm.$^{-1}$ (C=O); 1405 cm.$^{-1}$ ($COCH_2$) and 1360 cm.$^{-1}$ ($COCH_3$) (picrate, m.p. 120–122°). On exposure to 0.1 *N* sodium hydroxide, III underwent retroaldol cleavage to acetone and a ketone (IV), infrared peak at 1723 cm.$^{-1}$ (CS_2), 1730 cm.$^{-1}$ (CCl_4); $[\alpha]^{25}D$ +17° (*c* 1.43 in H_2O) (di-*p*-toluoyl-D-tartrate, m.p. 149–151°). Treatment of IV with ethanedithiol and then desulfurization produced tropane (V), picrate, m.p. 280–288° (dec.); chloroplatinate, m.p. 208–210°, identical with authentic samples.[10] The ketone IV is therefore tropan-2-one or tropan-6-one. We initially preferred[11] the 6-substituted structure, mainly because of the position of the carbonyl band in the infrared of IV. Reduction with sodium borohydride or with hydrogen over Adams catalyst yielded an alcohol (VI), m.p. 70° (picrate, m.p. 262–263°; di-*p*-toluoyl-D-tartrate, m.p. 165–166°; di-*p*-toluoyl-L-tartrate, m.p. 164–165°) which had an infrared spectrum entirely different from that of a mixture of 6α- and 6β-hydroxytropane, m.p. 65–81° (*cf.* ref. 9) prepared by desulfurization of 6β-hydroxytropan-3-one thioketal. The three derivatives of the alcohol from dioscorine (I), however, were identical with those of 2α-hydroxytropane (VI).[12] Similarly the di-*p*-toluoyl-D-tartrates of IV from cocaine and dioscorine were identical. The nuclear magnetic resonance spectrum of dioscorine (in $CHCl_3$) has no peaks above 1200 c.p.s.[13] and unactivated methyls are therefore absent.

The configuration at C_2 then was determined: The saturated diol prepared by catalytic reduction of II had a pK_a of 8.81 (Cellosolve) like 2α-hydroxytropane (VI), pK_a 8.42, while 2β-hydroxytropane (VII) had pK_a 9.62. The observed differences in basicity are similar to those of quinine and epiquinine[14] and demonstrate that the tertiary hydroxyl in II has the α-configuration which is in agreement with the previously reported infrared evidence.[8] 2β-Hydroxytropane (VII), m.p. ∼−10°, $n^{20}D$ 1.4862 (picrate, m.p. 263–265°) was prepared by lithium aluminum hydride reduction of 2β,3β-epoxytropane (IX) (picrate, m.p. 248–254°) which in turn was available by oxidation of tropidine (VIII) with trifluoroperacetic acid in acetonitrile.[15] The conversion of both cocaine[12] and dioscorine to the same tropan-2-one (IV) demonstrates identical absolute configuration[16] in the two alkaloids.



IV, $R_1, R_2 = O$
V, $R_1 = H$, $R_2 = H$
VI, $R_1 = H$, $R_2 = OH$
VII, $R_1 = OH$, $R_2 = H$

We are indebted to Eli Lilly and Co. for financial support and to Prof. E. Schlittler for plant material.

DEPARTMENT OF CHEMISTRY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASSACHUSETTS

D. E. AYER
G. BÜCHI
P. REYNOLDS-WARNHOFF
DWAIN M. WHITE

RECEIVED OCTOBER 6, 1958

---

[1] H. W. Schütte, *Chem. Zentr.*, **68**, II, 130 (1897).

[2] M. K. Gorter, *Rec. trav. chim.*, **30**, 161 (1911).

[3] A. R. Pinder, *Nature*, **168**, 1090 (1951).

[4] A. R. Pinder, *J. Chem. Soc.*, 2236 (1952).

[5] A. R. Pinder, *ibid.*, 1825 (1953).

[6] A. R. Pinder, *ibid.*, 1577 (1956).

[7] A. R. Pinder, *Chemistry and Industry*, 1240 (1957).

[8] A. R. Pinder, *Tetrahedron*, **1**, 301 (1957).

[9] J. B. Jones and A. R. Pinder, *Chemistry and Industry*, 1000 (1958).

[10] K. Hess, *Ber.*, **51**, 1001 (1918); R. Willstätter and F. Iglauer, *ibid.*, **33**, 1170 (1900).

[11] G. Büchi, D. E. Ayer and D. M. White, XVIth Intern. Congr. of Pure and Applied Chemistry, Paris, July, 1957.

[12] M. R. Bell and S. Archer, accompanying paper. We wish to thank Dr. S. Archer for a sample of this substance.

[13] Relative to an arbitrarily assigned peak of 1000 c.p.s. for the aromatic proton of toluene.

[14] V. Prelog and O. Häfliger, *Helv. Chim. Acta*, **33**, 2021 (1950).

[15] Method of G. Fodor, J. Toth, I. Koczor, P. Dobo and I. Vincze, *Chemistry and Industry*, 764 (1956).

[16] E. Hardegger and H. Ott, *Helv. Chim. Acta*, **38**, 312 (1955).