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STRUCTURE OF MONASCORUBRIN

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Abstract—The structure V has been derived for monascorubrin.

THE orange pigment monascorubrin and the yellow pigment monascoflavin were first isolated by one of us (E. N.)[1] in 1926 from *Monascus purpureus* Wentii. They are widely used for coloring foodstuff in Asia and are aslo identical with the main constituent pigments of the popular Taiwan wine, Hong-Ru,[2] which is made from steamed hulled rice inoculated with the mold. We had been studying these pigments since late 1957 and proposed I as a probable structure for monascorubrin.[2] Some time earlier it was shown by Professor Robertson *et al.*[4] that monascorubrin and monascoflavin[5] had been isolated from various strains of *Monascus*, together with the related pigments, sclerotiorin, rotiorin and rubropunctatin, for which structures II[6], III[6] and IV[7], respectively, have recently been forwarded.

The mild action of ammonia on monascorubrin simply converts the pyronoid oxygen atom into —NH— to give monascamine[8] (monascorubramine),[4] which in turn affords monascaminone[8] (apomonascorubramine[4]) when treated with zinc in various madia. The structural studies were first carried out on monascaminone since neither monascorubrin nor monascamine gave suitable crystalline derivatives. A detailed UV spectroscopic comparison of monascaminone derivatives with models[9] suggested a 7-hydroxyisoquinoline structure (VI) which meant that monascorubrin should be represented by I[3]; the complicated keto-enol tautomerism of monascamine and derivatives[9] could also be rationalized in a satisfactory manner. However, the alternative structure

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[1] E. Nishikawa, *J. Agric. Chem. Soc. Japan* **2**, 688 (1926); **8**, 1007 (1932).

[2] We are grateful to Professor F. C. Chen, National Taiwan University, for sending us the Taiwan samples.

[3] K. Nakanishi, M. Ohashi, S. Kumasaki and S. Yamamura, *J. Amer. Chem. Soc.* **81**, 6339 (1959).

[4] A. D. G. Powell, A. Robertson and W. B. Whalley, *Chem. Soc.* (Special Publ.) No. 5, p. 27 (1956).

[5] H. Salomon and P. Karrer, *Helv. Chim. Acta* **15**, 18 (1931); A. Geiger and P. Karrer, *Ibid.* **24**, 289 (1941). The yellow pigment is designated "Monascin" in these papers, but since this name has already been used for a red pigment isolated from *Monascus Paxii* Lingelsheim (Lingelsheim, *Hedwigia* **57**, 253 (1916)), we prefer to use the name "monascoflavin".

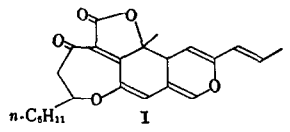
[6] F. M. Dean, J. Staunton and W. B. Whalley, *J. Chem. Soc.* 3004 (1959).

[7] E. J. Haws, J. S. E. Holker, A. Kelley, A. D. G. Powell and A. Robertson, *J. Chem. Soc.* 3598 (1959).

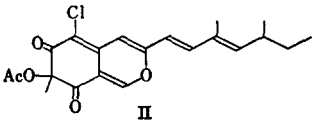
[8] M. Ohashi, S. Kumasaki, S. Yamamura, K. Nakanishi and H. Koike, *J. Amer. Chem. Soc.* **81**, 6339 (1959).

[9] Following paper.

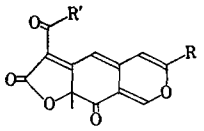
[10] B. C. Fielding, E. J. Haws, J. S. E. Holker, A. D. G. Powell, A. Robertson and W. B. Whalley, *Tetrahedron Letters* No. 5, p. 24 (1960).



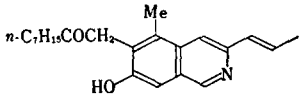
I



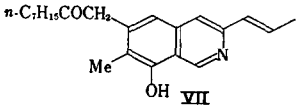
II



III R : $-CH=CH-C(CH_3)=CH-C(CH_3)CH_2CH_3$
R' : $-CH_3$
IV R : $-CH=CHCH_3$, R' : n-$C_5H_{11}-$
V R : $-CH=CHCH_3$, R' : n-C_7H_5-



VI



VII

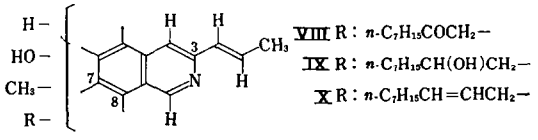
(V) was subsequently proposed in 1960[10] on the basis of the similarity between monascorubrin and rubropunctatatin (IV), and this meant that monascaminone should be the 8-hydroxyisoquinoline derivative (VII). The NMR spectra described in this paper are indeed in favor of structure V, and thus the UV spectra of monascaminone and derivatives as compared to those of model hydroxyisoquinolines possess features that require further investigation.[9]

It was originally regarded[1] that *M. purpureus* Wentii first produces monascorubrin, which is then converted into monascoflavin, and that oxidation of the former with hydrogen peroxide also yields the latter. Although it is true that the relative amount of monascoflavin increases with longer cultivation, this is probably due to decomposition of monascorubrin resulting from the increase in pH.[11] The monascorubrin sample is tenaciously contaminated with monascoflavin, as shown by the characteristic 1786 cm^{-1} IR band (in chloroform) of the latter, and this can only be removed after repeated recrystallizations; since monascoflavin is more stable to hydrogen peroxide than monascroubrin, treatment of a mixture of the two with this reagent selectively destroys the latter. In fact, this was the simplest way to obtain pure monascoflavin. Hence, it appears that some of the samples used before had been mixtures. The British "monascorubrin" has been reported to be a mixture with rubropunctatin,[10] which still persists in various derivatives. The IR spectrum of their "monascorubrin" is identical with ours,[12] and although the possibility of our sample also being contaminated with rubropunctatin cannot be discarded completely, this seems rather improbable because: (a) in spite of many attempts we were unable to isolate any rubropunctatin from our strain, (b) boiling dihydromonascorubrin with alkali furnished n-octanoic acid and no n-hexanoic acid, and (c) Beckmann rearrangement followed by hydrolysis of monascaminone oxime gave only the n-heptylamine, which would not have been the case had the oxime been a mixture with the corresponding rubropunctatin derivative.

The following evidence on monascaminone leads to part structure VIII.[8] The spectroscopic data are as follows: λ_{max}^{EtOH} 253, 302, 352 mμ (log ε 4·73, 3·95, 3·78); ν_{max}^{KBr} 3000–2750 (br, OH), 1710 (s, C=O), 1654 (m, C=C), 1630 (s, C=N), 1590 and 1570 cm^{-1} (arom.). The IR spectrum of the hydrochloride possessed an immonium peak[13] at 1903 cm^{-1} (KBr) besides the ammonium band, and hence an N-heterocyclic

[11] M. Kurono, K. Nakanishi, K. Shindo and M. Tada, *Chem. Pharm. Bull* **11**. No. 6 (1963). In press.
[12] We are indebted to Professor Whalley for the exchange of samples of monascorubrin.
[13] B. Witkop, *J. Amer. Chem. Soc.* **76**, 5597 (1954).

aromatic nucleus was present. Hydrogenation with Pd-charcoal afforded the dihydro compound, which was obtained also by the reaction of dihydromonascamine with zinc and acetic acid. The UV spectrum of dihydromonascaminone showed that it was a substituted isoquinoline: λ_{max}^{EtOH} 239, 288 triplet, 343 mμ (log ε 4·69, 3·53, 3·69). Hydrogenation over Adams catalyst gave octahydromonascaminone, the phenolic character of which was indicated by positive ferric chloride and diazo coupling reactions, spectroscopic data, and formation of a triacetate with IR bands (in chloroform) at 1754 (enol acetate), 1740 (acetate) and 1651 cm^{-1} (N-acetate); the IR of the hydrochloride at 2900, 2620, and 2560 cm^{-1} (nujol) suggested it to be a secondary amine.[14] Thus the pyridine portion of the isoquinoline nucleus, the carbonyl group and the side chain double bond had been reduced in octahydromonascaminone. Oxidation of mona-



scaminone with potassium permanganate yielded berberonic acid, i.e., pyridine-2,4,5-tricarboxylic acid. These evidences showed that monascaminone was an isoquinoline substituted by a hydroxyl group at positions 5–8. Acetaldehyde was obtained in high yield from the ozonolysis of monascaminone, but not from that of the dihydro compound, and since the respective UV peaks of the latter were shifted by ca. 10 mμ towards shorter wave lengths, a propenyl side chain is directly attached to the nucleus. Ozonolysis of monascaminone acetate yielded acetaldehyde and a solid; the latter was further oxidized with hydrogen peroxide to O-acetylmonascaminoic acid, which gave an orange color with ferrous sulfate, a reaction typical for α-carboxy pyridines.[15] Thus the propenyl chain is attached to C-3. When the oxime was subjected to Beckmann rearrangement and hydrolysis, n-heptylamine was produced as the sole volatile product (identified as picrate). Reduction of monascaminone with sodium borohydride gave monascaminol (IX), which was dehydrated to dehydromonascaminol (X) when heated in polyphosphoric acid at 150°; since the UV maxima of X were located at longer wave lengths in comparison to monascaminone, the dehydration had formed a new double bond in conjugation with the nucleus. The NMR spectrum of monascaminone in pyridine is consistent with the part structure VIII derived from these evidences: [Figs in τ-values] 9·1 (terminal Me), 8·8 (—CH_2—), 8·1 (doublet, propenyl Me), ca. 7·6 (partly superimposed on 7·4 singlet, active CH_2 that is γ to nucleus), 7·4 (singlet, arom. Me), 5·9 (singlet, active CH_2 that is α to nucleus).

An attempt was made to determine the location of the hydroxyl group in monascaminone by comparisons of the UV spectra with 5, 6, 7, and 8-hydroxyisoquinoline derivatives.[9] The 5- and 6-hydroxy structures could be discarded easily, and of the remaining alternatives a 7-hydroxyisoquinoline framework appeared to be preferred over an 8-hydroxy structure. However, structures given in the sequel mainly refer to those derived from the 8-hydroxy structure because of the nuclear magnetic resonance evidence acquired at a later stage.

The mild action of ammonia or methylamine on monascorubrin (V) at room temperature converted it smoothly into monascamine (XI) or N-methylmonascamine (XII)

[14] K. Nakanishi, T. Goto and M. Ohashi, *Bull. Chem. Soc., Japan* **30**, 403 (1957).
[15] H. Ley, Chr. Schwarte and O. Münnich, *Ber.* **57**, 349 (1924).

in which the UV maxima had been shifted towards the red. These facts coupled with the general similarity of IR peaks (Table 1) and the secondary ammonium type IR spectrum[14] of monascamine hydrochloride indicated that the conversion merely involved an exchange of —O— for —NR (R=H or Me) and that pyronoid, pyridonoid or their vinylogous structures were very probably involved. Monascorubrin and monascamine when hydrogenated over Pd-$BaSO_4$ furnished dihydro compounds having UV curves somewhat displaced towards the blue; band IV (Table 1) had also disappeared and these facts suggested a double bond that was conjugated to a terminal position of the chromophore had been reduced. Monascaminone (VII) is formed from monascamine by the action of zinc under both acidic and basic conditions, and

TABLE 1. INFRARED PEAKS OF MONASCORUBRIN AND DERIVATIVES (IN CM^{-1})

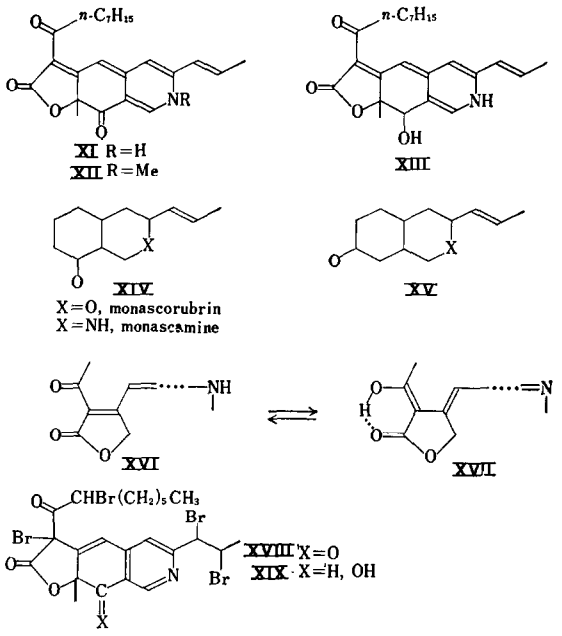
Compound	Medium	I (lactone)	II (ketone)	III (C_8—C=O)	IV (C=C)
Monascorubrin	CCl_4	1759	1729	1659	1639
Dihydromonascorubrin	CCl_4	1759	1729	1664	none
Monascamine	CCl_4	1734	1705	1611	1654
Dihydromonascamine	nujol	1735	1711	1643	none
N-Methylmonascamine	CCl_4	1734	1712	1640	
Isodihydromonascamine	KBr	1703	none*	none	
Tetrabromomonascamine	KBr	1796	1742	?	none
Tetrabromo-isodihydromonascamine	KBr	1795	1750† 1725	none	none

* Exists in enolic form.

† Relative intensities of these two bands varied according to conditions of measurement; in $CHCl_3$ and nujol, the 1750 and 1725 bands, respectively, were reduced to shoulders. The phenomenon is tentatively attributed to equilibrium between rotational isomers.

it is also formed by alkali fusion of isodihydromonascamine (XIII), the sodium borohydride reduction product of monascamine. This formation of monascaminone under a variety of conditions indicated that no rearrangement had occurred and that the skeleton of monascamine, and thus monascorubrin, had been retained. Hence the 8- or 7-hydroxyisoquinoline structure of monascaminone suggested that the nuclei of monascorubrin and monascamine could also be formulated as in XIV or XV.

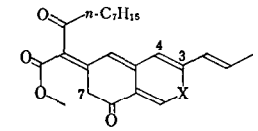
Since monascaminone does not contain a lactone group, it is clear that the carbon dioxide (one mole) evolved during its formation originates from the lactone in monascamine that has its IR band at 1734 cm^{-1}. The 1760 and 1730 cm^{-1} bands of monascorubrin are both shifted to lower wave numbers by 20–25 cm^{-1} in monascamine. The fact that the same shifts were still observed in N-methyl-monascamine showed that they were not due to the formation of an intramolecular C=O · · · H—N hydrogen bonding; instead it indicated that the lactone and ketone groups were both conjugated with the hetero atom. Although the UV and IR data of monascamine and isodihydromonascamine were extremely sensitive to conditions of measurement, the confusing results could be interpreted satisfactorily by keto enol tautomerism of a cross-conjugated β-keto-lactone moiety that is conjugated to the ring nitrogen[9] (XVI, XVII). Monascamine (XI) and isodihydromonascamine (XIII) gave tetrabromo derivatives (XVIII, XIX) when reacted with bromine in glacial acetic acid, and although definite structures could not be assigned to them at the outset, the very high position



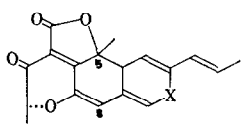
of the IR band—I seemed to demonstrate the presence of an α-bromo-γ-lactone; accordingly the lactone is expressed as five membered in formula XVI.

Noting that the IR peaks I, II and III are displaced to lower wave numbers in monascamine, and that band III is absent in isodihydromascamine, one can combine part structures VIII, XIV and XVI to give the expression XX. All three carbonyl functions are in conjugation with the hetero atom X and the three IR peaks can be assigned to the γ-lactone, side-chain ketone, and annular ketone, respectively, in order of decreasing frequencies. The double bond between C_3 and C_4 follows from the fact that the propenyl side-chain should also be conjugated to the chromophore (mentioned above). The remaining nuclear methyl group of monascaminone (VIII) and the γ-lactone should both be attached to C_7; otherwise enolization involving the C_8-carbonyl leads to a stable isoquinoline nucleus, which would certainly have been detected during the spectroscopic studies[9] on the keto-enol tautomerism of monascamine. Thus monascorubrin is represented by V, monascamine by XI, isodihydromonascamine by XIII, and monascaminone by VII.

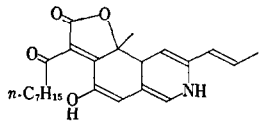
On the other hand, on the basis of the 7-hydroxyisoquinoline skeleton XV, the IR peak III must be assigned to an enol ether because a carbonyl placed at C_7 cannot conjugate with the ring hetero atom. Thus XXI is derived, in which the only possible linkage of the enol ether is to some point in the saturated aliphatic side-chain. The position of the methyl group of monascaminone (VIII) is restricted to C_5 because the positive diazo coupling of monascaminone requires C_8 to be vacant. The ethereal ring was considered to be seven-membered as shown in I[3] in order to account for the production of both n-hexanoic acid and n-octanoic acid by oxidation with alkaline hydrogen peroxide (see below). The corresponding structure for isodihydromonascamine would then be XXII (or its tautomer) and that for monascaminone would be VI. However, these structures are not compatible with the nuclear magnetic resonance results described below.



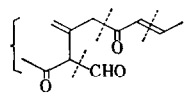
XX X=O or NR



XXI X=O or NR



XXII



XXIII

When monascorubrin was refluxed in 2N potassium hydroxide for one hour there was obtained acetaldehyde, formic acid, acetic acid, and crotonic acid; on the other hand, boiling of dihydromonascorubrin for 8 hours in 10% aqueous alkali yielded butyric acid and n-octanoic acid (no n-hexanoic acid, see below) identified as *p*-bromophenacyl esters. Retro-aldol cleavage and vinylogous β-diketone cleavages occurring at the dotted positions shown in the intermediate of type XXIII would lead to the mentioned products other than octanoic acid. Oxidation of monascorubrin with alkaline hydrogen peroxide yielded n-hexanoic and n-octanoic acids identified as their *p*-bromophenacyl esters. The production of two acids is peculiar and we now think that the sample used for this particular reaction must have contained the difficulty separable monascoflavin. Hydrogenolysis of the ozonides of monascorubrin gave acetaldehyde and a trace of n-hexanoic acid and n-octanoic acid, whilst that of dihydromonascorubrin gave no acetaldehyde and only a trace of n-butyric acid (from side-chain). Methylglyoxal was identified as the 2,4-dinitrophenylhydrazone when the ozonide was decomposed with water; this product presumably arises from the C_7-methyl by a secondary decomposition of an intermediate polyketone.[16]

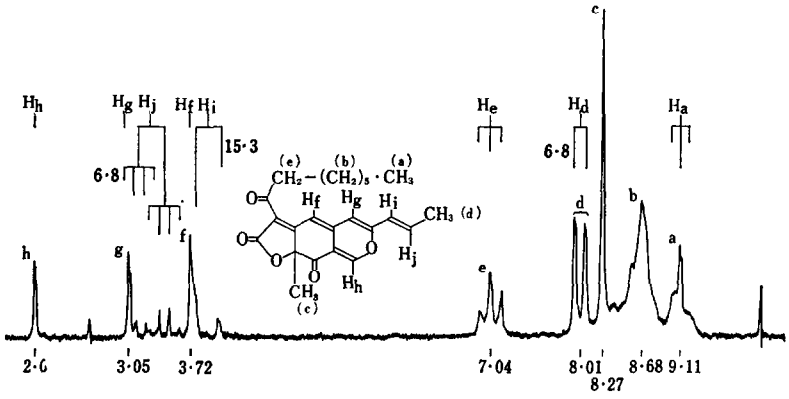
TABLE 2. NMR PEAKS OF MONASCORUBRIN AND DERIVATIVES (IN τ VALUES).

Proton signals (intensity)	Monasco-rubrin (V)	Dihydromonasco-rubrin	Monascamine (XI)	Isodihydro-monascamine (XIV = XXV)
	in $CDCl_3$	in $CDCl_3$	in pyridine	in pyridine
a (3)	9·11 (t)	9·11 (t)	9·11 (t)	9·15 (t)
b (10)	8·68 (b)	8·69 (b)	8·66 (b)	8·66 (b)
c (3)	8·27 (s)	8·27 (s)	8·12 (s)	8·30 (s)
d (3)	8·02 (d)	8·98 (t)	8·0 (d)	8·18 (d)
k (2)		7·52 (t)		
e (2)	7·04 (t)	7·04 (t)	6·63 (t)	6·60 (t)
m (1)				4·78 (s)
f (1)	3·72 (s)	3·74 (s)	3·47 (s)	3·62 (s)
i (1)	3·86 (m)			
j (1)	3·35 (m)			
g (1)	3·05 (s)	3·11 (s)	3·12 (s)	3·28 (s)
h (1)	2·01 (s)	2·03 (s)	1·50 (s)	1·98 (s)

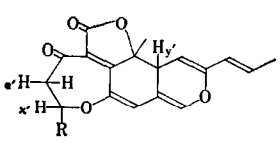
Abbreviations: b, broad; d, doublet; m, multiplet; s, singlet; t, triplet.

The NMR data shown in Table 2 are in full agreement with formula V for monascorubrin (Fig. I) and structures XI and XIII derived thereof for monascamine and

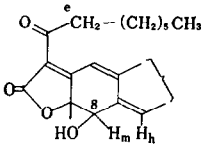
[16] M. M. Shemyakin and L. A. Schukina, *Quart. Rev.* **10**, 261 (1956).



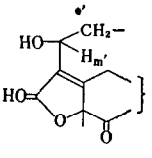
isodihydromascamine. The position of the lowest signal (h) at τ 2·01 in monascorubrin corresponds to the α-protons of γ-pyrones, which appear at τ 2·5 and can be differentiated from the β-protons (τ 4·1)[17]; the lowering is due to the neighboring carbonyl group. The (i) and (j) peaks comprise the AB component of an ABX_3 type[18] trans-propenyl side-chain,[19] the X_3 component appearing as the doublet (d): J_{ij} 15·3 cps, J_{dj} 6·8 cps. The lower field of the H_j signal in comparison to that of H_i is either due to the conjugative effect of the carbonyl groups or the anisotropic effect of the nearby C—O bond. In dihydromonascorubrin the H_i and H_j signals disappear and H_d becomes a triplet; the new H_k triplet is the α-methylene of the n-propyl side-chain. The alternative structure I (XIV) is inconsistent in the following respects: (i) The (e')-protons would appear as the complicated AB component of an ABX system, and not as the observed τ 7·04 triplet; (ii) $H_{x'}$ is intensively coupled and the signal should appear as a broad band in the τ 4–6 region; (iii) $H_{y'}$ signal would appear around τ 7·0. Since



XXIV



XXV = XIII



XXVI

all peaks present in monascorubrin are still found in monascamine, it is apparent that the change only involves exchange of oxygen for nitrogen (H_i and H_j peaks are overlapped by pyridine peaks). The characteristics of the spectrum of isodihydromonascamine (XIII = XXV) are that : H_h is shifted by 0·5 ppm to higher fields as compared to monascamine (XI); a new singlet H_m appears at τ 4·78; and triplet (e) remains unchanged. The constancy of triplet (e) is consistent only with the conversion of XI to XXV and not with conversions of XXIV to XXII, or XI to XXVI; also if XXVI were the structure for isodihydromonascamine the $H_{m'}$ signal would not appear as the observed singlet at τ 4·78. The shift to higher fields of peak (h) can be ascribed to the disappearance of the anisotropic effect[20] of the C_8-carbonyl in monascamine.

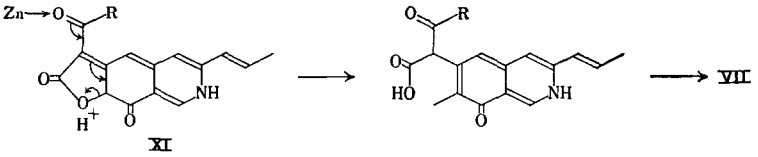
[17] M. Ohashi, A. Terahara and K. Nakanishi, *Bull. Chem. Soc. Japan* **33**, 1311 (1960).

[18] H. J. Bernstein, J. A. Pople and W. G. Schneider, *Canad. J. Chem.* **35**, 65 (1957).

[19] cf. L. M. Jackman, *Application of Nuclear Magnetic Resonance Spectroscopy in Organic Chemistry* p. 92. Pergamon press, London (1959).

[20] S. Goodwin, J. N. Shoolery and L. F. Johnson, *J. Amer. Chem. Soc.* **81**, 3065 (1959).

The conversion of monascamine (XI) to monascaminone (VII) with zinc could proceed by the following mechanism:[21]



XI

EXPERIMENTAL

M.p. were determined on a micro hot-stage and are uncorrected. The UV spectra were measured with Beckmann DK-2 and Hitachi EP-2 recording spectrophotometers. The IR spectra were measured with Hilger H-800 and Nihon Bunko 301 spectrophotometers, equipped with rocksalt prisms. The NMR spectra were measured with Varian V-4300 (at 56·4 Mc) and A-60 (at 60 Mc) models.

Monascorubrin

The material used for structural studies was that collected by one of us (E. N.) about 25 years ago and stored in a can. As it was contaminated with monascoflavin, it was repeatedly recrystallized from ethanol until the characteristic IR peak of monascoflavin at 1786 cm^{-1} (in $CHCl_3$) had completely disappeared. The combined mother liquors were preserved for isolation of monascoflavin. Needles, m.p. 134–135°, $[\alpha]_{700}^{16}$ −1500° (*c* 0·1% in ethanol). λ_{max}^{MeOH} 221, 260, 385, 470, 500, 556 mμ (log ε 4·21, 4·22, 4·52, 3·95, 3·99, 4·12). IR spectrum (CCl_4): 1759, 1729, 1659, 1639, 1584 cm^{-1}. (Found: C, 72·2, 72·2; H, 6·66, 6·59; $C_{23}H_{26}O_5$ requires: C, 72·2; H, 6·58%). C-Methyl: 9·87, 10·3, 9·90% (2·5, 2·6, 2·5 moles). It was soluble in ether, methanol, ethanol, benzene, chloroform, acetic acid and acetone, and insoluble in water and pet ether. The orange ethanolic solution of this compound became purple in alkali and yellow in acid.

Ozonolysis of monascorubrin

(a) A stream of 2% ozone was passed through a solution of 0·5 g monascorubrin in 30 ml ethyl acetate under cooling with acetone–dry ice for 3·5 hr. The pale blue solution was treated with 1 g 10% palladium charcoal and shaken with hydrogen until the hydrogen uptake ceased (for 25 min, 87 ml of gas uptake). The solvent was distilled into a solution of 2,4-dinitrophenylhydrazine hydrochloride, and the hydrazone was purified by chromatography on alumina, crystallized from methanol and identified as acetaldehyde 2,4-dinitrophenylhydrazone by IR spectrum and mixed m.p. The residue was paper-chromatographed on Toyo filter paper No. 51, using butanol saturated with 1·5 N NH_4OH as solvent; R_f, 0·73, 0·59 and 0·12, were identical with that of octanoic, hexanoic and acetic acid, respectively.

(b) A stream of 2% ozone was passed through a solution of 1 g monascorubrin in 30 ml chloroform at 0° for 6 hr and the solvent removed *in vacuo*. The residue was boiled with 30 ml water, the distillate was passed through a solution of 2,4-dinitrophenylhydrazine hydrochloride and the hydrazone was crystallized from ethanol. It was identified as acetaldehyde 2,4-dinitrophenylhydrazone by IR spectrum and mixed m.p. Another hydrazone that was insoluble in ethanol deposited more slowly; since its alkaline acetone solution gave a blue color, it should be the bishydrazone of an α-diketone. Crystallization from nitrobenzene gave a few mg of crystals, m.p. 312°, identified as methyglyoxal bis-2,4-dinitrophenylhydrazone by IR spectrum. The distillation residue was extracted with ether and ether layer was extracted with 0·1 N NaOH. After acidification with sulfuric acid, the aqueous solution was re-extracted with ether. Removal of the solvent gave a syrup and paper-chromatography on Toyo filter paper No. 51, with the usual solvent gave spots with R_f 0·58 and 0·70 (hexanoic and octanoic acid, respectively).

Degradation of monascorubrin with alkali

Monascorubrin (0·6 g) was heated with 50 ml 2N KOH under a stream of nitrogen for 1 hr with addition of sufficient distilled water to maintain the volume. The nitrogen stream and distillate (30 ml)

[21] R. B. Woodward, F. E. Bader, H. Bader, H. Bickel, A. J. Frey and R. W. Kierstead, *Tetrahedron* **2**, 1 (1958).

were introduced into saturated solutions of 2,4-dinitrophenylhydrazine in 2N HCl, the hydrazones were combined, dried in a vacuum dessicator, a chromatographed on alumina and eluted with benzene. The resulting 2,4-dinitrophenylhydrazone, m.p. 160° (methanol) was identified by IR spectrum as acetaldehyde 2,4-dinitrophenylhydrazone (0·04 g). After cooling, the residual alkaline solution was acidified with 2N H_2SO_4 and distilled. The distillate contained formic acid as detected by the pink chromotropic acid test and black mercuric chloride test. After adding a few drops of conc aqueous ammonia to the distillate the water was removed *in vacuo*; acetic acid and crotonic acid were detected from the residue by paper-chromatography on Toyo filter paper No. 51, using butanol saturated with 1·5N NH_4OH as solvent.

Oxidation of monascorubrin with hydrogen peroxide

To a solution of 5 g monascorubrin in 2 ml ethanol containing 0·3 g potassium hydroxide, there was added dropwise 2 ml 30% hydrogen peroxide. A vigorous reaction set in and the temp rose accompanied by foaming. After the reaction had ceased, the excess hydrogen peroxide was decomposed with 10% palladium charcoal. The pale yellow solution was separated from the solid by filtration, acidified and extracted with ether. Removal of ether furnished 1 ml of an acidic oil, b.p. 170–200°. This oil was converted into its *p*-bromophenacyl ester and chromatographed by the method described for the alkaline degradation products of dihydromonascorubrin (see below). Fraction Nos. 45–60 gave 0·035 g *p*-bromophenacyloctanoate, m.p. 67–67·5°, identified by mixed m.p. and IR spectrum. Fraction Nos. 77–105 gave 0·041 g *p*-bromophenacylhexanoate, m.p. 71·5–72°, also identified by mixed m.p. and IR spectrum.

Dihydromonascorubrin

According to Nishikawa's method, monascorubrin (2 g) in 100 ml ether was shaken in hydrogen at room temperature in the presence of 1 g 5% Pd-$BaSO_4$. Working up the solution gave 1 g dihydromonascorubrin as golden plates, m.p. 93–94° (from ethanol), λ_{max}^{MeOH} 261, 295, 364, 438, 465, 525 mμ (log ε 4·53, 4·14, 4·63, 4·12, 4·21, 4·43). IR spectrum (CC_4): 1759, 1729, 1664, 1589 cm^{-1}. (Found: C, 71·6; H, 7·35. $C_{23}H_{28}O_5$ requires: C, 71·9; H, 7·34%).

Ozonolysis of dihydromonascorubrin

A stream of 2% ozone was passed through a solution of 0·34 g dihydromonascorubrin in 20 ml chloroform at −5° for 4 hr. The solvent was removed *in vacuo* and the residual gum was dissolved in 20 ml ethyl acetate and shaken with hydrogen in the presence of 0·15 g 10% palladium charcoal until the hydrogen uptake had ceased (3 equivs of hydrogen were consumed). After removal of the solvent, 30 ml water was added to the residual oil and distilled into an aqueous solution of 2,4-dinitrophenylhydrazine hydrochloride. This gave only a minute amount of hydrazone in which acetaldehyde could not be detected. Butyric acid was detected from distillation residue by paper-chromatography with the butanol-1·5N ammonia system, R_f 0·35.

Degradation of dihydromonascorubrin with alkali

Dihydromonascorubrin (1 g) was heated with 50 ml 10% aqueous sodium hydroxide on the water bath in a current of nitrogen for 8 hr with the addition of sufficient distilled water to maintain a constant volume. The nitrogen was passed through an aqueous solution of 2,4-dinitrophenylhydrazine hydrochloride, giving a very small amount of undetectable crude hydrazone; the residual dark brown solution was acidified with 2N H_2SO_4 and stream-distilled. This distillate (30 ml) was neutralized with 0·09 g sodium carbonate and evaporated to dryness *in vacuo*. The residue was refluxed for 1 hr in 6 ml water, 12 ml ethanol and 0·6 g *p*-bromophenacylbromide. Dilution with 20 ml water gave precipitates which were dissolved in benzene and filtered. After removal of the solvent, the residue was taken up in a small volume of ligroin–benzene (1:1) and chromatographed on silicic acid–supercell (3:1) column (1 × 46 cm) with the same solvent mixture (1 ml cutting per 15 min). After removal of solvent from each fraction, the m.p. of the residue was measured and the fractions having identical m.p. were collected and purified (ethanol–water). Fraction Nos. 65–85 yielded *p*-bromophenacyl octanoate (0·02 g), m.p. 66·5°, identified by mixed m.p. and IR spectrum, whereas fraction Nos. 149–214 gave *p*-bromophenacyl butyrate (0·03 g), m.p. 63–64°, also identified by mixed m.p. and IR spectrum.

Monascamine

Monascorubrin (0·5 g) suspended in 5 ml of ethanol was rapidly dissolved in 10 ml conc aqueous ammonia with vigorous stirring at 0°. After 5 min, the deep purple solution was diluted with 30 ml water and weakly acidified with 2N HCl at 0° to give precipitates. Recrystallization of the well-washed precipitates from acetic acid gave monascamine as purple plates (0·39 g), m.p. 192° (dec) frothing after softing from 180°. IR spectrum (KBr): 1736, 1705, 1660 (w), 1625, 1613 cm^{-1}. (Found: C, 72·0, 72·2; H, 7·07, 6·93; N, 3·67. $C_{23}H_{27}O_4N$ requires: C, 72·4; H, 7·13; N, 3·67%).

Monascamine hydrochloride

Monascamine was recrystallized from a mixture of acetic acid and 6N HCl (1:1), giving red yellow plates, m.p. 198–202°. Recrystallization from acetic acid gave back monascamine, IR spectrum (nujol): 2720 (br), 1745, 1718, 1648 (w), 1590, 1490 cm^{-1}. (Found: C, 66·0; H, 6·51; N, 3·82. $C_{23}H_{27}O_4N \cdot HCl$ requires: C, 66·1; H, 6·25; N, 3·35%).

Tetrabromomonascamine

A solution of bromine in acetic acid was added to a solution of 80 mg monascamine in 3 ml acetic acid until the red color was no longer discharged. The solution was poured into ice water and the precipitates were crystallized from methanol giving colorless needles (70 mg), m.p. 88–91°. λ_{max}^{MeOH} 234, 297 mμ (log ε 4·37, 4·23). (Found: C, 40·2; H, 4·16. $C_{23}H_{27}O_4NBr_4$ requires: C, 39·4; H, 3·86%).

N-*Methylmonascamine*

Monascorubrin was treated with a 40% aqueous solution of methylamine according to the method for the preparation of monascamine from monascorubrin. The solution was poured into water and precipitates were purified by chromatography on acid-washed alumina, upon which there were obtained a powder softening at 105°. IR spectrum (nujol): 1725, 1708, 1633, 1542, 1522 cm^{-1}. (Found: C, 70·2; H, 7·15; N, 3·88. $C_{24}H_{29}O_4N \cdot H_2O$ requires: C, 69·7; H, 7·56; N, 3·39%).

Dihydromonascamine

Dihydromonascorubrin (0·4 g) was treated with conc aqueous ammonia as described for the production of monascamine. The crude dihydromonascamine (0·4 g) was recrystallized from methanol, m.p. 119–121°. IR spectrum (KBr): 1739, 1715, 1643, 1619, 1582, 1534 cm^{-1}. (Found: C, 72·0; H, 7·68; N, 3·21. $C_{23}H_{29}O_4N$ requires: C, 72·0; H, 7·62; N, 3·65%).

Isodihydromonascamine

An aqueous solution (5 ml) of 100 mg sodium borohydride was added dropwise to a solution of 0·5 g monascamine in ethanol and allowed to stand overnight. The solution was poured into dil. hydrochloric acid and the precipitates were recrystallized from ethanol, m.p. 218–220° (410 mg). The crystals gave a green color with aqueous ferric chloride and a purple color with tetrazo-diortho-anisidine and sodium carbonate. λ_{max}^{MeOH} 235, 287, 302, 392, 478 (log ε 4·25, 4·26, 4·12, 4·14, 4·31). IR spectrum (KBr): 3200–3100, 1703, 1652, 1638, 1594 cm^{-1}. (Found: C, 72·1; H, 7·57; N, 3·74. $C_{23}H_{29}O_4N$ requires: C, 72·0; H, 7·26; N, 3·63%).

Tetrabromoisodihydromonascamine

Isodihydromonascamine (100 mg) was treated with bromine similarly as described for the preparation of tetrabromomonascamine. Colorless needles, 0·13 g, m.p. 138–140° (methanol). λ_{max}^{MeOH} 233, 290, (log ε 4·16, 4·10). IR spectrum (nujol): 3300, 1795, 1742, 1645, 1637, 1600 cm^{-1}. (Found: C, 40·3; H, 3·38. $C_{23}H_{27}O_4NBr_4$ requires: C, 39·4; H, 3·87%).

Monascamine

(a) A solution of 1·42 g monascamine in 5 ml pyridine containing 2 g zinc dust and 2 ml acetic acid was stirred under cooling in a stream of nitrogen when the original purple color changed to orange. The nitrogen was passed through saturated aqueous barium hydroxide to give 0·65 g barium carbonate (0·84 mole). After 20 min, the mixture was poured into a large amount of water (100 ml) with vigorous stirring. The orange solid was dissolved in hot benzene–ether (1:1), separated from

unchanged zinc dust by filtration, and recrystallized from the same solvent when 0·85 g monascaminone was obtained as colorless needles, m.p. 186°. $[\alpha]_D$ 0° (*c.* 0·35 in 1:1 ethanol–benzene). λ_{max}^{MeOH} 253, 302, 352 mμ (log ε 4·73, 3·95, 3·78). IR spectrum (KBr): 3000–2750, 1710, 1654, 1630, 1590, 1570 cm^{-1}. (Found: C, 77·8, 77·9; H, 8·86, 8·50; N, 4·08, 4·30. $C_{22}H_{29}O_2N$ requires: C, 77·8; H, 8·61; N, 4·13%).

(b) Conc aqueous ammonia (5 ml) was added dropwise to a solution of 0·4 g monascamine in 10 ml ethanol containing 1 g zinc dust. After 5 min, the excess zinc dust was removed and the filtrate was diluted with 50 ml water and acidified with acetic acid. The precipitates (0·15 g) were collected and crystallized from ethanol, m.p. 184–186°. The crystals were identified as being monascaminone by mixed m.p. and IR spectra.

(c) To a mixture of 0·04 g monascamine and 0·1 g zinc dust in 5 ml ethanol, there was added 1 ml acetic acid and after 5 min, this solution was poured into water and the precipitates were recrystallized from ethanol to give 10 mg monascaminone as colorless needles. Monascaminone is soluble in 2N NaOH, exhibits a green color with ferric chloride, and couples with tetrazo-diorthoanisidine to give a red color. Acidification of an ethanolic solution of 0·5 g monascaminone with 3N HCl gave bright yellow precipitates of 0·55 g of the hydrochloride, which separated from ethanol containing hydrochloric acid as bright yellow plates, m.p. 164–165°. IR spectrum (KBr): 3110, 2535, 2380, 2018, 1903, 1713, 1660, 1635, 1618 cm^{-1}.

Ozonolysis of monascaminone

A stream of 3% ozone was passed through a suspension of 0·55 g monascaminone in 30 ml chloroform at 0° until one equiv had been consumed. An orange solution was obtained. The solvent was removed *in vacuo* and the ozonide was decomposed with 50 ml water. The aqueous liquor was decanted from an orange solid and distilled into a solution of 2,4-dinitrophenylhydrazine hydrochloride, giving precipitates (0·1 g). Crystallization from ethanol gave yellow needles, m.p. 160°, which was identified as acetaldehyde 2,4-dinitrophenylhydrazone by mixed m.p. and IR spectrum.

Oxidation of monascaminone with potassium permanganate

Powdered potassium permanganate was added in small portions to a suspension of 0·94 g monascaminone in 50 ml water at room temp until the color was no longer discharged (2·8 g of reagent, 5 days). The excess potassium permanganate was decomposed with 10 ml ethanol. The precipitated manganese dioxide was removed by filtration, washed with 100 ml hot water, and the combined filtrate was concentrated to 30 ml *in vacuo*, acidified with hydrochloric acid, and extracted with ether. n-Caproic acid and n-octanoic acid were detected from the etheral solution by paper-chromatography (n-butanol saturated with 1·5N NH_4OH), R_f 0·77 and 0·87. The aqueous solution was evaporated to dryness *in vacuo* and the residual solid was washed with 40 ml of cold water, which when recrystallized from water gave brownish solids (0·1 g) that did not melt up to 340°. A solution of this material in 50 ml water was shaken with an ion exchange resin Dowex 50-X8 (H-form, 0·5 g) for 30 min at 60° and treated with charcoal at 80°. The solution was concentrated to 5 ml under red. press. and was allowed to stand at 0°. Berberonic acid (pyridine-2,4,5-tricarboxylic acid) slowly separated as colorless prisms (0·04 g), dried *in vacuo* at 120° for 2 hr, m.p. 244–247° (dec), identical with an authentic specimen in mixed m.p. and IR spectrum.

Attempted reactions of monascaminone

(a) *Decomposition with alkali.* An oily suspension of 0·5 g monascaminone in 30 ml 2N NaOH was heated on a boiling water bath for 1 hr. Acidification with 2N HCl gave 0·45 g unreacetd monascaminone hydrochloride.

(b) *Cyclization with acid.* Monascaminone (1 g) was recovered unchanged when it was heated with polyphosphoric acid (2 g) at 150–160° for 1·5 hr, or when 0·15 g in 3 ml orthophosphoric acid was heated at 120° for 20 min. Monascaminone was also unaffected when 0·1 g of its hydrochloride was refluxed for 3 hr in 3 ml dioxane and 1 ml conc hydrochloric acid.

(c) *Oxidation with hydrogen peroxide.* A solution of 0·1 g monascaminone in 20 ml acetone containing 1·5 ml 30% hydrogen peroxide was refluxed for 1 hr, the solvent was removed *in vacuo* 50 ml water was added, and the precipitates (0·09 g) were purified from ethanol, giving unchanged monascaminone.

Monascaminone acetate

Admixture of 0·5 g monascaminone, 20 ml acetic anhydride and 10 ml pyridine formed a red solution, which was left at room temp for 15 hr, and poured into 150 ml water. The precipitates were collected, washed with 50 ml water and purified from aqueous methanol, giving acetylmonascaminone as colorless solids, m.p. 76–79°. IR spectrum (KBr): 1760, 1705, 1654, 1633, 1587, 1568, 1200 cm^{-1}. (Found: C, 75·3; H, 7·98; N, 3·33. $C_{24}H_{31}O_3N$ requires: C, 75·6; H, 8·19; N, 3·67%).

Ozonolysis of O-acetylmonascaminone

A slow stream of ozone was passed through a solution of 0·5 g acetylmonascaminone in chloroform at 0° for 90 min. Removal of the solvent *in vacuo* followed by decomposition of the ozonide with 25 ml water furnished a pale yellow solid. When the aqueous hydrolysate was distilled into a solution of 2,4-dinitrophenylhydrazine hydrochloride, yellow precipitates of acetaldehyde 2,4-dinitrophenylhydrazone separated, identified by m.p. and IR spectrum.

The solid obtained from the ozonide was suspended in 20 ml acetone containing 5 ml water, treated with 1·5 ml 30% aqueous hydrogen peroxide, and refluxed for 1 hr. Removal of the bulk of acetone under red. press. followed by addition of 20 ml water furnished a precipitate which was recrystallized from chloroform–benzene–ethanol (1:1:1), giving pale yellow micro-needles (0·3 g), m.p. 230–232°. It is very sparingly soluble in alcohol, benzene, acetone and chloroform, and insoluble in saturated aqueous sodium hydrogen carbonate or cold 2N NaOH. With ferrous sulfate it gives a bright orange color in ethanol and chloroform. IR spectrum (KBr): 2540–2333, 1761, 1710, 1636, 1575, 1200 cm^{-1}. (Found: C, 67·2, 67·3; H, 6·82, 6·72; N, 3·19, 3·20. $C_{21}H_{25}O_5N$ requires: C, 67·9; H, 6·78; N, 3·77%). A solution of this material in benzene and ethanol was acidified with an excess of hydrochloric acid and evaporated to dryness *in vacuo* giving the hydrochloride as a colorless solid, m.p. 126–138°. IR spectrum (KBr): 2386–2311, 1786, 1721, 1709, 1621, 1587, 1171 cm^{-1}.

Methoxy monascamine

Tetrahydrofuran (20 ml) saturated with diazomethane was added to a solution of 0·45 g monascaminone in 20 ml tetrahydrofuran and allowed to stand 2 days. The solvent was removed and the residual oil was purified by chromatography on neutralized alumina and eluted with benzene. Evaporation of the elute yielded methoxymonascaminone as colorless needles, which were recrystallized from aqueous ethanol m.p. 60°. IR spectrum (KBr): 1708, 1664, 1626, 1585, 1563 cm^{-1}. λ_{max}^{MeOH}: 250, 280, 290, 301, 341 $m\mu$ (log ε 4·74, 4·20, 4·24, 4·12, 3·33). (Found: C, 77·5; H, 8·70; N, 3·79. $C_{23}H_{31}O_2N$ requires: C, 87·1; H, 8·84; N, 3·68%).

Methoxyhexahydromonascaminone

A solution of 1·22 g methoxymonascaminone in 75 ml ethanol containing a drop of hydrochloric acid was hydrogenated with 0·16 g Adams' catalyst until 250 ml hydrogen was absorbed. Removal of catalyst and solvent gave methoxyhexahydromonascaminone hydrochloride as colorless needles, m.p. 120°. IR spectrum (KBr): 2750, 1714, 1616, 1583 cm^{-1}. (Found: C, 70·2; H, 10·08; N, 3·89. $C_{23}H_{37}O_2N \cdot HCl$ requires: C, 69·7; H, 9·66; N, 3·53%).

Dihydromonascaminone

(a) *From monascaminone.* A solution of 0·5 g monascaminone in 100 ml ethanol containing 0·25 g 10% palladium charcoal was shaken in hydrogen. When the gas absorption had stopped (7 min, 52 ml), the catalyst was removed and the filtrate was condensed *in vacuo*. Dihydromonascaminone (0·1 g) was obtained as colorless needles (0·21 g), m.p. 97–98° (ether–pet ether).

(b) *From dihydromonascamine.* To a solution of 0·1 g dihydromonascamine in 2 ml ethanol there was added 2 ml aqueous ammonia with shaking. After 5 min, the deep purple solution was diluted with 10 ml water and acidified with 2N HCl. When this solution was saturated with sodium chloride, a red precipitate separated. The dried precipitate was dissolved in 3 ml pyridine and the solution was heated with 0·2 g zinc dust and 3 ml acetic acid with vigorous shaking. When the exothermic reaction had ceased, the excess zinc was removed, the solution was diluted with 30 ml water and saturated with sodium chloride, when colorless precipitates separated. The precipitates were collected and purified by means of chromatography on alumina. Elution with benzene containing a few drops of

methanol gave 30 mg dihydromonascaminone, m.p. 97°, which was identical with the material produced by method (a). λ_{max}^{MeOH}: 239, 288, 343 mμ (log ε 4·69, 3·53, 3·69). IR spectrum (nujol): 3000–2500, 1717, 1637, 1603, 1566 cm^{-1}. (Found: C, 76·6; H, 9·03. $C_{22}H_{31}O_2N$ requires: C, 77·4; H, 9·15%).

Dihydromonascaminone acetate

A solution of 110 mg dihydromonascaminone in 1 ml pyridine containing 2 ml acetic anhydride was allowed to stand overnight, and poured dropwise into a large amount of water under cooling. The liberated oil was extracted with ether, the ether layer was washed with water, dried over sodium sulfate, concentrated *in vacuo* and the residual syrup was slowly crystallized from methanol (70 ml), m.p. 52–54°. λ_{max}^{EtOH} 233, 266 (triplet), 320, 333 mμ (log ε 4·71, 3·61, 3·49, 3·54). IR spectrum (KBr): 1748, 1725, 1642, 1601, 1568 cm^{-1}. (Found: C, 75·0; H, 8·56. $C_{24}H_{33}O_3N$ requires: C, 75·2; 8·67%).

Dihydromonascaminol

An ethanolic solution of 0·25 g dihydromonascaminone containing 0·1 g 10% palladium charcoal was shaken with hydrogen until gas absorption had ceased (30 min, 35 ml). After removal of the catalyst, the solution was concentrated *in vacuo*, and the dihydromonascaminol (0·12 g) was crystallized from ethanol, m.p. 154–155°, IR spectrum (KBr): 1626, 1600, 1564 cm^{-1}. (Found: C, 77·5; H, 9·49. $C_{22}H_{33}O_2N$ requires: C, 76·9; H, 9·68%).

Monascaminone oxime

A solution of 0·5 g monascaminone in 5 ml ethanol was mixed with an aqueous solution of 0·5 g hydroxylamine hydrochloride and 1 g sodium acetate and refluxed for 3 hr. The solvent was removed *in vacuo* and residue was diluted with water to give crude monascaminone oxime, which was recrystallized from ethanol. Further purification was carried out by chromatography on alumina and elution with ether containing a few drops of methanol, colorless needles, m.p. 211–213°.

Beckmann rearrangement of monascaminone oxime

(a) A suspension of 0·17 g monascaminone oxime in 3 g polyphosphoric acid was heated at 150° for 10 min, the cooled solution was diluted with water and the precipitates were purified from a mixture of ethanol and water. The amorphous solid had an IR spectrum that showed the presence of an amide group (1636 and 1543 cm^{-1}). This amide was suspended in 60% sulfuric acid and refluxed for 30 min. After being cooled, the acidic solution was made alkaline with 1N NaOH with cooling in ice water. The resulting alkaline solution was steam distilled, the distillate was extracted with ether, the ether was evaporated and the residue was submitted to paper-chromatography on Toyo filter paper No. 51, developed with acetic acid–butanol–water (1:4:1), R_f 0·84. R_f values of authentic amines: *hexylamine* 0·80; *heptylamine* 0·84; *octylamine* 0·85; *butylamine* 0·70. This amine was converted into the picrate (3 mg), m.p. 116–117°, which was identified as heptylamine picrate by mixed m.p. and IR spectrum.

(b) To a suspension of 0·2 g monascaminone oxime in 5 ml ether, 2 ml thionyl chloride was added and the mixture was evaporated to dryness on the water bath. The resulting black syrup was suspended in 50% sulfuric acid and refluxed for 10 min. The solution was made alkaline with aqueous sodium hydroxide and steam distilled. The distillate was extracted with ether. The solvent was removed and the residue was submitted to paper-chromatography. Heptylamine was identified from the R_f value, 0·85.

Octahydromonascaminone

A suspension of 0·6 g monascaminone in 50 ml ethanol was shaken with hydrogen and 0·29 g platinum oxide for 15 hr, upon which a clear solution was obtained and the hydrogen uptake had ceased. Removal of the solvent *in vacuo* furnished brownish crystals, which upon recrystallization from ethanol gave 0·065 g octahydromonascaminone as colorless prisms, m.p. 181–182°. It gave a red purple color with ferric chloride and a red color with tetrazo-diorthoanisidine. λ_{max}^{EtOH} 226, 282 mμ (log ε 3·90, 3·11). IR spectrum (KBr): 3500–2500, 3242, 1617, 1578, 1494, 1236, 1202, 1128, 1081 cm^{-1}. (Found: C, 76·3; H, 10·92; N, 4·12. $C_{22}H_{37}N_2O$ requires: C, 76·0; H, 10·73; N, 4·03%).

To a solution of this material in ethanol there was added a drop of conc hydrochloric acid and the solution was evaporated to dryness *in vacuo*. The residue slowly crystallized giving octahydromonascaminone hydrochloride, m.p. 157–158°. IR spectrum (nujol): 3360, 2900, 2620, 2560, 1623, 1605, 1590, 1500 cm^{-1}. Acetylation with pyridine and acetic anhydride gave colorless needles, m.p. 60–62°. IR spectrum ($CHCl_3$): 1754 (vinyl acetate), 1740 (acetate), 1651 (amide) cm^{-1}.

Monascaminol

(a) A solution of 0·35 g sodium borohydride in 10 ml water was added to a suspension of 1 g monascaminone in 20 ml ethanol. After standing 3 hr, this solution was neutralized with dil. hydrochloric acid and the liberated monascaminol was recrystallized from ethanol (0·7 g), m.p. 196–197°.

(b) Lithium aluminum hydride (0·3 g) was added to a solution of 1 g monascaminone in 30 ml dry tetrahydrofuran and shaken vigorously, when the complex precipitated immediately. The solvent was evaporated *in vacuo*, the residual aqueous solution was acidified with acetic acid, and the monascaminol (0·6 g) was crystallized from methanol, m.p. 196–197°, λ_{max}^{MeOH} 256, 307, 352 mμ (log ε 4·80, 3·88, 3·77). IR spectrum (nujol): 3200, 1656, 1639, 1589, 1561 cm^{-1}. (Found: C, 77·1, 76·9; H, 9·28, 9·10; N, 4·31. $C_{22}H_{31}O_2N$ requires: C, 77·4, H; 9·15; N, 4·10%).

Monascaminol diacetate

Acetylation of 0·15 g monascaminol with 1·5 ml pyridine and 3 ml acetic anhydride gave 0·1 g diacetylmonascaminol which was recrystallized from methanol, m.p. 69–70°. (Found: C, 69·9; H, 8·59; N, 4·02. $C_{26}H_{35}O_4N \cdot H_2O$ requires: C, 70·4; H, 8·41; N, 3·16).

Monascaminol ditosylate

A mixture of 0·4 g monascaminol and 1·6 g *p*-toluene sulfochloride in 10 ml pyridine was allowed to stand 3 days. The solution was added dropwise to 70 ml ice water, extracted with chloroform and the chloroform layer washed with 5% sodium hydrogen carbonate and dried over sodium sulfate. After removal of the solvent, the residue was recrystallized from methanol, 0·3 g, m.p. 115–116°. IR spectrum (nujol): 1655, 1631, 1592, 1559 cm^{-1}. (Found: C, 66·5; H, 6·57; N, 2·42. $C_{36}H_{43}O_6NS_2$ requires: C, 66·6; H, 6·67; N, 2·16%).

Dehydromonascaminol

Monascaminol (0·1 g) was heated at 150° for 30 min with a mixture of 2 ml orthophosphoric acid and 1 g phosphorous pentoxide. After cooling, the mixture was poured into water and the precipitates were shaken with saturated aqueous sodium hydrogen carbonate, washed with water and recrystallized from ethanol, m.p. 192–193° (0·03). λ_{max}^{MeOH} 225, 262, 318, 352 mμ (log ε 4·33, 4·59, 3·75, 3·69). IR spectrum (nujol): 1662, 1627, 1597, 1576 cm^{-1}. It gave a green color with ferric chloride and a pink color with tetrazo-diorthoanisidine.

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