The Structure of Nuttalline, an Alkaloid Constituent of *Lupinus nuttallii*

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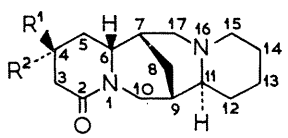
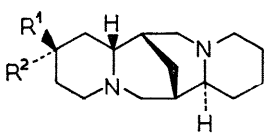
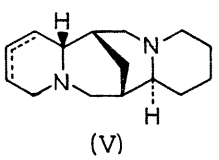
ALONG with the several major alkaloids elaborated by *Lupinus nuttallii* we have isolated a hitherto unknown minor base which we have named nuttalline: $C_{15}H_{24}N_2O_2$†; *m/e* 264 (M^+); m.p. 108—109°; $[\alpha]_D^{26}$ 25·3 ± 0·9° (*c* 2·00 in ethanol); u.v. (EtOH): 208 nm. (ε 5600); i.r. (CCl_4): 3480, 1012 (axial OH), 2810, 2760 (*trans*-quinolizidine), and 1650 cm.$^{-1}$ (lactam C=O); monoperchlorate salt, m.p. 170—172°.



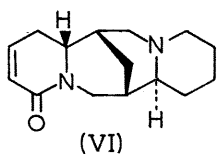
	R^1	R^2
(I)	OH	H
(III)	O	
(VII)	H	H



	R^1	R^2
(II)	OH	H
(IV)	H	H
(VIII)	H	OH



(V)



(VI)

We report now on our work that has established nuttalline as (+)-4α-hydroxy-2-oxosparteine (**I**), the first example of a 2,4-dioxygenated sparteine.

The i.r. spectrum of nuttalline indicated the presence of a hydroxy and a lactam function, accounting for the two oxygen atoms. The first hint of the relative disposition of the two functions was given when nuttalline failed to undergo clean reduction by lithium aluminium hydride, while it was reduced by prolonged treatment with sodium borohydride to deoxonuttalline [(−)-4α-hydroxysparteine (**II**)]: $C_{15}H_{26}N_2O$; *m/e* 250 (M^+); $[\alpha]_D^{26}$ −9·10 ± 0·70 (*c* 1·70 in ethanol); u.v. (EtOH): 207 nm. (ε 5000); i.r. ($CHCl_3$): 3600, 1020 (axial OH), 2800, and 2780 cm.$^{-1}$ (*trans*-quinolizidine); monoperchlorate salt, m.p. 248—250°. These results could be interpreted in terms of initial interaction of the hydride reducing agent with the hydroxy-group to form an internal alkoxymetal hydride which, in the case of borohydride, delivered hydride to the juxtaposed lactam function to form a carbinolamine which underwent elimination to enamine followed by borohydride reduction to (**II**). The course followed in the lithium aluminium hydride reaction was evidently more complicated since an array of products was obtained. The 1,3-arrangement of oxygen functions thus suggested was confirmed by Oppenauer oxidation of nuttalline to a ketolactam [2,4-dioxosparteine

† Satisfactory combustion analyses were obtained for all key compounds.

(**III**)] that exhibited the characteristic pH-dependence of β-dicarbonyl compounds in its u.v. spectrum and showed the presence of an enol grouping in its i.r. spectrum.

The tetracyclic skeletal arrangement present in nuttalline was established as that of (−)-sparteine (**IV**) when the latter was obtained *via* dehydration of deoxonuttaline (**II**) by phosphorus pentoxide to didehydrodeoxodeoxynuttalline [3,4- or 4,5-didehydrosparteine (**V**)] followed by catalytic hydrogenation. A similar sequence of reactions was used to determine the position of the lactam carbonyl. Phosphorus pentoxide dehydration of nuttalline gave deoxydidehydronuttalline [(+)-2-oxo-3,4-didehydrosparteine (**VI**)]: $C_{15}H_{22}N_2O$; *m/e* 246 (M^+); $[\alpha]_D^{24}$ 57·2 ± 0·60° (*c* 2·00 in ethanol); i.r. (CCl_4): 3125, 1650, and 1550 cm.$^{-1}$ (CH:CHCON); n.m.r. ($CDCl_3$); δ 5·5 (1H multiplet) and 4·55 (1H apparent doublet), which upon catalytic hydrogenation was converted into deoxynuttalline, identified as (+)-lupanine [(+)-2-oxosparteine (**VII**)] by direct comparison with authentic material.

All evidence pointed to (**I**) as the structure of nuttalline. This assignment was further reinforced by the fact that the i.r. spectrum determined from deoxonuttalline (**II**) differed from that of the known 4β-hydroxysparteine (**VIII**)[1] only in the C–O bending region, so that it did indeed appear that the two were epimeric. Rigorous evidence in support of this conclusion—and, therefore, in confirmation of the assignment of (**I**) as the structure of nuttalline—was afforded by the formation of (**VIII**) by lithium aluminium hydride reduction of the keto-lactam (**III**), a result in accord with the known steric course of hydride reduction of 4-oxosparteine.[1]

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[1] S. I. Goldberg and R. F. Moates, *J. Org. Chem.*, 1967, **32**, 1832.