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# COUPLING CONSTANTS IN 1,3-DIOXOLANS AND 1,3-DIOXANS: THE STRUCTURE OF DELPHINIUM ALKALOIDS CONTAINING A METHYLENEDIOXY GROUP

T. A. Crabb,
College of Technology, Portsmouth,

R. C. Cookson,
The University, Southampton.

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Of the highly oxygenated, hexacyclic Aconite and Larkspur alkaloids the only group the structure of which is still not clear consists of those containing a methylenedioxy group: delpheline (1, 2), deltaline (3) (= eldeline (4)), deltamine (3) (= eldelidine (4)), elatine (5), and elatidine (5).

Delpheline is hydrolysed by acid to formaldehyde and demethylenedelpheline (6), the structure of which (I, R = H) is certain because it has been unambiguously related to lycoctonine (3, 7). The structure of the latter (II) is based on complete X-ray analysis (8).

The doubt concerns the relation of delpheline to demethylenedelpheline. We suggested two alternative structures for delpheline, either III, R = H, or IV, R = H, according to whether or not rearrangement accompanied hydrolysis (6). Although IV, R = H, could not be excluded, III, R = H, was favoured because some demethyleneoxodelpheline* was isolated from oxidation of delpheline with permanganate and chromatography on alumina. Its formation in this way, perhaps by oxidation of the methylenedioxy group to the orthoformate and hydrolysis, was thought unlikely to involve rearrangement.

Since elimination of acetic acid from diacetyl-deltamine gave an olefin that yielded acetyl delpheline on hydrogenation, and demethylenedeltamine was converted by two moles of periodic acid into a di-seco-$\gamma$-lactone, Carmack and his colleagues (9) concluded that the extra hydroxyl group in demethylenedeltamine must be located at R in formula I. Kuzovkov and Platonova (10) reached the same conclusion from parallel reactions of demethyleneoxoeldelidine. Through an unjustified appeal to Bredt's rule it was then claimed (9) that deltamine could not have the lycoctonine skeleton (III, R = OH) but must be IV, R = OH, which had undergone the rearrangement we had suggested as a

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* In the oxo-derivatives the $CH_2$-N group has been converted to CO-N.

possibility during hydrolysis to the demethylene derivative (I, R = OH). Correspondingly delpheline had to be IV, R = H. We now show that delpheline has structure III, R = H, not IV, R = H, and therefore that deltamine (eldelidine) is III, R = OH, not IV, R = OH.

As demonstrated by the examples in the Table, for methylenedioxy groups whose protons have different chemical shifts, in five-membered rings the coupling constant is between 0 and 2 c/s, whereas in six-membered rings it is about 6 c/s (sign undetermined, but presumably negative).

The low coupling constant for the methylene protons in delpheline and its derivatives clearly shows that they are on a five-membered ring. Acid isomerises oxodelpheline to isooxodelpheline, which contains a tertiary hydroxyl group in place of the secondary one in its precursor. Further treatment hydrolyses it to demethyleneoxodelpheline and formaldehyde. The larger coupling constant in isooxodelpheline, probably indicating a six-membered methylenedioxy ring, is consistent with the tentative suggestion (6) that it has structure V.

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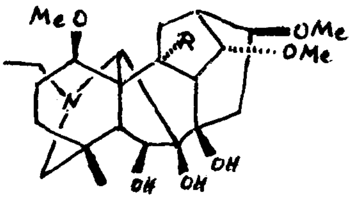
TABLE

| Compound | Solvent | Chemical shift[x] ($\tau$) | | | | J (c/s) |
|---|---|---|---|---|---|---|
| VI, R = $CH_3$ | $CCl_4$ | | 5.00 | 5.17 | | 0.4 |
| VI, R = $C_6H_5$ | $CCl_4$ | | 4.89 | 5.09 | | 0 |
| VI, R = $CH_2Cl$[b] | $CDCl_3$ | | 4.93 | 5.07 | | 0 |
| VI, R = $CH_2OCONHC_6H_5$ | $CDCl_3$ | | 4.97 | 5.11 | | 0 |
| VII | $CCl_4$ | | 4.94 | 5.19 | | 1 |
| 17α,20,21-Bismethylenedioxypregna-1,4-dien-3,11-dione[a] (VIII) | $CDCl_3$ | 4.79 | 4.94 | 4.95 | 4.98 | 0 |
| 17α,20,21-Bismethylenedioxy-11β-methoxypregn-4-en-3-one[s] | $CDCl_3$ | 4.79 | 4.93 | 4.96 | 4.96 | 0 |
| 17α,20,21-Bismethylenedioxy-3α-ethynylpregn-4-en-11-one[s] | $CDCl_3$ | 4.79 | 4.92 | 4.92 | 4.97 | 0 |
| Otobain (11) (IX) | $CDCl_3$ | | 4.36 | 4.42 | | 1.5 |
| Dicentrine (12) (X) | $CDCl_3$ | | 3.9 | 4.05 | | 1-2 |
| XI, R = $CH_3$, R' = H | $CCl_4$ | | 5.11 | 5.42 | | 6.1 |
| XI, R = $C_6H_5$, R' = H | $CCl_4$ | | 4.92 | 5.31 | | 6 |

**TABLE contd.**

| **Compound** | **Solvent** | **Chemical shift[*] (τ)** | | **J (c/s)** |
|---|---|---|---|---|
| XI, R = H, R' = $OCOC_6H_5$ | $CCl_4$ | 5.16 | 5.24 | 6.2 |
| XI, R = H, R' = $OCONHC_6H_5$ | $CDCl_3$ | 4.98 | 5.20 | 6.2 |
| XI, R = H, R' = $OSO_2C_6H_4CH_3$-p | $CCl_4$ | 5.29 | 5.38 | 6 |
| XI, R = $C_6H_4OCH_3$-p, R' = $CH_3$ | $CDCl_3$ | 4.84 | 5.22 | 6.3 |
| XII | $CCl_4$ | 5.01 | 5.49 | 6 |
| XIII | $CCl_4$ | 5.26 | 5.43 | 5.8 |
| XIV (13) | $CHCl_3$ | 4.85 | 5.23 | 6.25 |
| XV$^{o}$ | $CCl_4$ | 5.23 | 5.31 | 6 |
| XVI$^{o}$ | $CDCl_3$ | 4.85 | 5.17 | 6.6 |
| XVII$^{o}$ | $CDCl_3$ | 5.00 | 5.37 | 6.5 |
| XVIII$^{o}$ | $CDCl_3$ | 5.01 | 5.38 | 6 |
| XIX$^{o}$ | $CDCl_3$ | 5.02 | 5.42 | 6.2 |
| Delpheline (III, R = H) | $CDCl_3$ | 4.88 | 4.96 | 0 |
| Oxodelpheline | $CDCl_3$ | 4.84 | 4.94 | 0 |
| Dehydrooxodelpheline | $CDCl_3$ | 4.51 | 4.91 | 1.4 |
| Isooxodelpheline | $CDCl_3$ | 4.85 | 5.01 | 4.3 |

[*] Chemical shifts in p.p.m. to lower field than tetramethylsilane as internal reference at 10.00.



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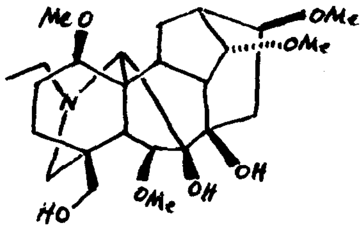

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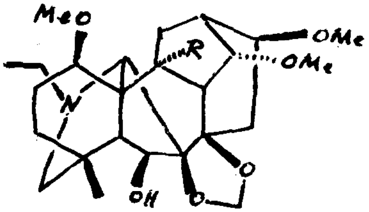

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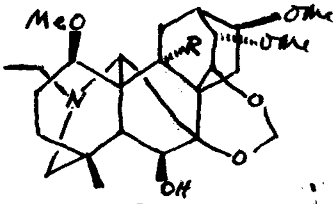

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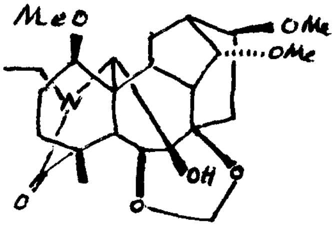

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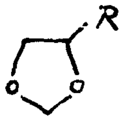

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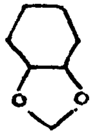

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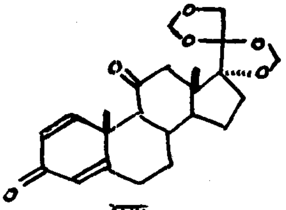

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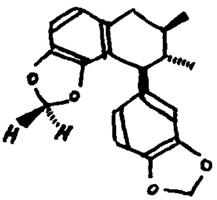

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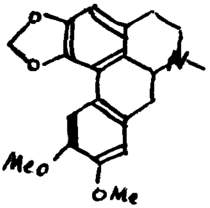

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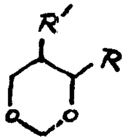

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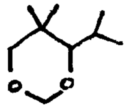

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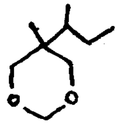

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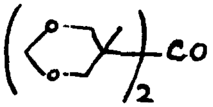

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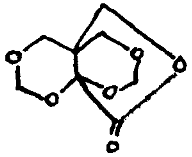

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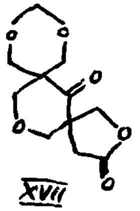

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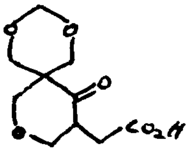

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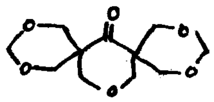

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