4. Some preliminary work on the oxidation of α,β-ethylenic nitriles is described.

5. Whereas the condensation of ethylene, propylene and α-butylene dichlorides with phenylacetonitrile gives cyclopropanecarbonitriles, the use of isobutylene dichloride under the same conditions leads to the formation of an ethylenic nitrile.

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The Molecular Weight of Cinobufagin

BY DOROTHY CROWFOOT AND H. JENSEN

It has been suggested[1] that cinobufagin ($C_{25}H_{32}O_6$) can be considered as the acetyl derivative of an unsaturated hydroxylactone, $C_{23}H_{30}O_5$, and apparently is closely related chemically to certain plant aglucones which are also C_{23} derivatives.[1] The x-ray crystallographic examination of this principle by Crowfoot[2] has given values, however, which do not agree with the proposed formula $C_{25}H_{32}O_6$ and which indicate that the compound probably contains twenty-six carbon atoms.

In order to check these results, x-ray measurements have now been made on two derivatives of cinobufagin, namely, acetylcinobufagin and cinobufagone. The measurements obtained on these compounds provide two independent determinations of the molecular weight of cinobufagin and both more nearly agree with the formulas derived from C_{26}. Thus the molecular weight of acetylcinobufagin was found to be 487 ± 10, the calculated values for the acetyl derivatives of $C_{26}H_{34}O_6$ and $C_{25}H_{32}O_6$ being, respectively, 484 and 470. Cinobufagone has a molecular weight of 443 ± 10 which is in agreement with the formula $C_{26}H_{32}O_6$, 440, and not $C_{25}H_{30}O_6$, 426. Details of the crystallographic measurements are given below.

The analytical values previously reported for cinobufagin and certain of its derivatives[3] agree with the formula $C_{26}H_{34}O_6$. This new formula would bring cinobufagin into very close relationship to bufotalin (present in the secretion of *Bufo vulgaris*) to which Wieland and co-workers[4] assigned the formula $C_{26}H_{36}O_6$ and which they showed can be considered as an acetyl derivative of an unsaturated hydroxylactone ($C_{24}H_{34}O_5$). It might be mentioned, in connection with this, that the results of the pharmacological studies by Chen and Chen[5] on the action of the various animal cardiac principles indicate that their physiological properties show more resemblance to the physiological action of scillaridin than of other plant aglucones. Chemical researches by Stoll and co-workers[6] have shown that scillaridin is a C_{24} derivative, while most other plant aglucones have been found to be C_{23} derivatives. The investigation of Wieland and co-workers[4] on bufotalin indicates that the lactone ring in the animal cardiac principles is a six-membered ring probably similar to that found by Stoll and co-workers[6] for scillaridin. In view of our findings on the molecular weight of cinobufagin, it appears that arenobufagin and regularobufagin are also probably C_{24} rather than C_{23} derivatives as originally suggested by Jensen.[7] Further research on the exact chemical composition of these two principles has been undertaken in order to answer this question.

It should be added that the crystallographic examination of cinobufagone and acetylcinobufagin alone would not exclude molecular weights of twice the magnitude deduced since the asymmetric unit in each case contains two C_{26} molecules. This possibility, however, is excluded by the original measurements on cinobufagin itself in which the single molecule is the asymmetric unit.

The actual crystal structures indicated by the measurements for cinobufagin, acetylcinobufagin and cinobufagone do not seem to bear very simple relation to one another or to those of any of the compounds in the cardiac aglucone series so far examined. This is not surprising since the introduction of many hydroxyl groups is known to produce considerable variation in the crystallo-

(1) Jensen, *Science*, **75**, 53 (1932).
(2) Crowfoot, *Chemistry & Industry*, **54**, 568 (1935).
(3) Jensen and Evans, Jr., *J. Biol. Chem.*, **104**, 307 (1934).
(4) Wieland and Hesse, *Ann.*, **517**, 22 (1935).
(5) Chen and Chen, *J. Pharmacol.*, **49**, 561 (1933).
(6) Stoll, Hofmann and Peyer, *Helv. Chim. Acta*, **18**, 1247 (1935).
(7) Jensen, THIS JOURNAL, **57**, 1765 (1935).

CRYSTALLOGRAPHIC DATA

Compound	Space group	a	b	c	No. in cell	No. asymmetric unit	Density	Mol. wt.
Cinobufagin	$P2_12_12_1$	7.61 α	15.79 γ	19.45 β	4	1	1.261	447 ± 10
Acetylcinobufagin	$C222_1$	28.74 γ	8.14 β	44.76 α	16	2	1.229	487 ± 10
Cinobufagone	$P2_12_12_1$	21.79 β	8.62 γ	24.22 α	8	2	1.280	443 ± 10

Acetylcinobufagin: fine orthorhombic needles elongated along (010), (001) dominating. Birefringence low.

Cinobufagone: small orthorhombic needles elongated along (010) and growing least on (001). The crystals appear partly redissolved and show curved surfaces instead of the c face. Birefringence low.

The densities of both compounds were determined by flotation in zinc sulfate solutions, the centrifuge being used to hasten equilibrium. These are correct to ±0.4%. The probable error on the x-ray dimensions is not more than ±0.5%.

graphic arrangement of the molecules as is found, for example, in the study of the sugars. Both the presence of the hydroxyl groups and the orthorhombic symmetry shown by the crystals of these cinobufagin compounds render it impossible to make deductions in regard to the molecular arrangement and molecular dimensions from the combination of the optical with the crystallographic data. One can only state that the data are not incompatible with formulas of the cardiac aglucone type and for comparison reference may be made to the complex crystal structures assumed by strophanthidin and certain of its derivatives.

Summary

The determinations of molecular weights of cinobufagin and two of its derivatives, acetylcinobufagin and cinobufagone, indicate that cinobufagin has the composition $C_{26}H_{34}O_6$. The analytical data previously reported for cinobufagin and certain of its derivatives agree with this new formula.

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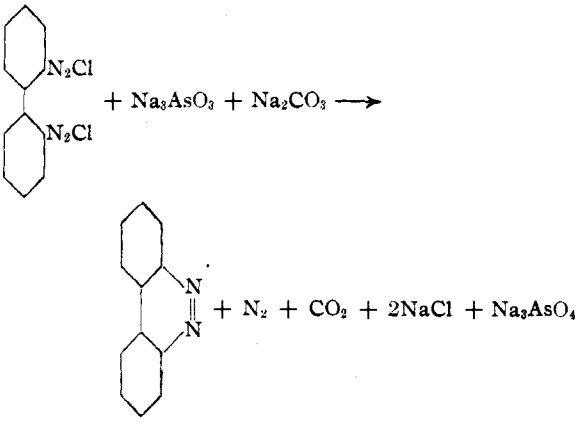
The Formation of Cyclic Azo Compounds from 2,2′-Diaminodiphenyls

BY R. B. SANDIN AND T. L. CAIRNS

The compound 4,4′-diarsonodiphenyl[1,2] has been prepared from benzidine, according to the method of Bart. In an attempt to prepare the isomeric 2,2′-diarsonodiphenyl by an analogous procedure, the authors of this paper have found that when tetrazotized 2,2′-diaminodiphenyl is treated with arsenious oxide in sodium carbonate solution, a considerable part of the tetrazotized compound is converted into *o,o′*-azodiphenyl.[3] The authors believe it to be a general reaction. It is also believed that the arsenite functions as a reducing agent instead of proceeding according to the typical Bart reaction.

The proposed equation for this reaction is



(1) Bauer and Adams, THIS JOURNAL, **46**, 1925 (1924).

(2) Hill, *ibid.*, **46**, 1855 (1924).

(3) This compound is also called phenazone and *o*-diphenyleneazone [Täuber, *Ber.*, **24**, 3081 (1891)]. Bigelow [*Chem. Rev.*, **9**, 117 (1931)] has suggested the name cyclic *o,o*-azoxydiphenyl, in place of diphenazonoxyd. For that reason it might, perhaps, be better to call phenazone or *o*-diphenyleneazone, cyclic *o,o*-azodiphenyl.

Experimental

Cyclic *o,o′*-Azodiphenyl.—In a mixture of 250 cc. of 2 *N* hydrochloric acid and 150 cc. of water, 18.4 g. of 2,2′-diaminodiphenyl was dissolved. The solution was cooled to 0°, and to it was added gradually 100 cc. of 2 *N* sodium nitrite and an excess of nitrite was maintained for thirty minutes. The clear solution of the tetrazotized compound