Tetrahedron. 1967. Vol. 23, pp. 2169 to 2172. Pergamon Press Ltd. Printed in Northern Ireland

IDENTIFICATION OF KETONES IN *CYPERUS**

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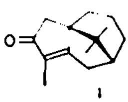
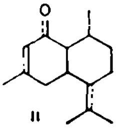
(*Received in Japan 20 September 1966; accepted for publication 24 October 1966*)

Abstract—A ketone isolated from *Cyperus scarosius* and isopatchoulenone (cyperenone) from *C. scariosus* have been identified as cyperotundone from *C. rotundus*. *C. articulatus* has also been shown to contain cyperotundone. Confusion in the previous report about the constituents of *C. articulatus* is clarified.

In recent communications,[1] we have proposed the stereostructure I for cyperotundone isolated from nutgrass (*Cyperus rotundus* Linné (Cyperaceae)) of Japanese origin. We have since noticed that in the genus *Cyperus* there has been reported the occurrence of sesquiterpenic ketones with similar properties to those of cyperotundone. The point of the present short communication is to record the identification of the ketones clarifying the complexity in the literature.


I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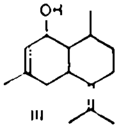
III

A ketone was isolated from *C. scarosius* R. Brown as the 2,4-dinitrophenylhydrazone, m.p. 228–229°[2] and a ketone (2,4-dinitrophenylhydrazone, m.p. 231–232°) from *C. articulatus* Linné;[3] both hydrazones being identified.[3] Direct comparison of the 2,4-dinitrophenylhydrazone of the ketone isolated from *C. scarosius* with cyperotundone 2,4-dinitrophenylhydrazone has confirmed them as identical. Therefore, the ketones from the three species of *Cyperus* genus must be all the same, i.e., cyperotundone.

However, Couchman *et al.*[3] reported that treatment of the 2,4-dinitrophenylhydrazone with conc hydrochloric acid and stannous chloride yielded a ketone which they called articulone and ascribed formula II. The reported physical and spectral properties of articulone are clearly different from those of cyperotundone. Since the NMR spectrum of cyperotundone 2,4-dinitrophenylhydrazone presently determined is consistent with that of cyperotundone but not with that of articulone, it is evident that no change has taken place during the preparation of the hydrazone. Therefore, it was naturally concluded that when the hydrazone was treated under the conditions

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* This paper forms Part XI in the series on Sesquiterpenoids. Part X, H. Hikino, Y. Takeshita, Y. Hikino, T. Takemoto and S. Itô, *Chem. Pharm. Bull.* in press.

[1] H. Hikino, K. Aota and T. Takemoto, *Chem. Pharm. Bull.* **13**, 628 (1965); **14**, 890 (1966).

[2] Y.-R. Naves and P. Ardizio, *Bull. Soc. Chim. Fr.* 332 (1954).

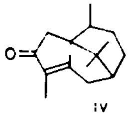
[3] F. M. Couchman, A. R. Pinder and N. H. Bromham, *Tetrahedron* **20**, 2037 (1964).

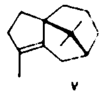
reported,[3] the 2,4-dinitrophenylhydrazone regenerated no cyperotundone but suffered rearrangement to articulone, articulone being an artifact.

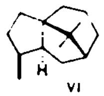
Couchman *et al.*[3] also reported that an alcohol fraction of the oil was oxidized with manganese dioxide to obtain a ketone which has the same IR spectrum as articulone and gave the 2,4-dinitrophenylhydrazone of m.p. 231–232°. On the basis of these results, they concluded that the original alcohol should have the structure III. The 2,4-dinitrophenylhydrazone of m.p. 231–232° has presently been identified as that of cyperotundone *via* that of Naves. However, a ketone having the same IR spectrum as articulone cannot give cyperotundone 2,4-dinitrophenylhydrazone and, on the other hand, a ketone giving cyperotundone 2,4-dinitrophenylhydrazone cannot show the same IR spectrum as articulone. This contradiction, therefore, threw doubt upon the above oxidation result.

At first being interested in the postulated rearrangement of cyperotundone to articulone some experiments were performed. Thus cyperotundone 2,4-dinitrophenylhydrazone was treated with conc hydrochloric acid and stannous chloride (the same and similar conditions reported[3]) and later with hydrochloric acid alone. In confirmation, cyperotundone was also treated as above and its 2,4-dinitrophenylhydrazone was treated with conc hydrochloric acid and aluminum chloride. Every treatment, however, failed and afforded only cyperotundone. In order to make sure, direct comparison of the 2,4-dinitrophenylhydrazone isolated from *C. articulatus* with cyperotundone 2,4-dinitrophenylhydrazone was carried out revealing that both hydrazones were identical as expected. After repeated correspondence with Dr. Pinder to solve this discrepancy, we at last arrived at the following conclusion. (1) The oil of *C. articulatus* contains cyperotundone which gives the 2,4-dinitrophenylhydrazone of m.p. 231–232°, reported. (2) The oil must also contain the other ketone, articulone, though it has not yet been obtained pure. The previous work was done on the ketone fraction, crude articulone, purified by distillation and chromatography but not on material purified *via* the 2,4-dinitrophenylhydrazone as reported. (3) The alcohol fraction used for manganese dioxide oxidation contained cyperotundone. The 2,4-dinitrophenylhydrazone (m.p. 231–232°) formed from the fraction after treatment with manganese dioxide originated from cyperotundone already present in that fraction before oxidation. It is not certain that the alcohol fraction contained the alcohol corresponding to cyperotundone or articulone. The detailed explanation of the confusion in the previous report will be published as the addendum of this paper.

Recently, Indian workers[4] isolated a ketone from *C. scariosus*, named isopatchoulenone, and proposed the constitution IV. Although isopatchoulenone has identical m.p. and optical rotation with those of cyperotundone and has been prepared from cyperene (V)[1] by oxidation, there are some differences between the properties of the two ketones as described below. (1) Isopatchoulenone gives no 2,4-dinitrophenylhydrazone, while cyperotundone affords a 2,4-dinitrophenylhydrazone. (2) The NMR


IV


V



VI

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[4] S. B. Merali, P. S. Kalsi, K. K. Chakravarti and S. C. Bhattacharyya, *Tetrahedron Letters* 4053 (1965).

spectrum of isopatchoulenone shows an AB quadruplet at 7·62 τ due to the C-2 methylene protons but that of cyperotundone does not exhibit such a signal. (3) The deoxo-derivative of dihydroisopatchoulenone is in the IR identical with the isopatchoulane obtained from α-patchoulene by hydrogenation. On the other hand, deoxodihydrocyperotundone is definitely different from the isopatchoulane (VI), dihydro-α-patchoulene, (VPC, IR and NMR spectra).[1] These differences suggested that isopatchoulenone might not be identical with cyperotundone. However, direct comparison of isopatchoulenone and its 2,4-dinitrophenylhydrazone, later prepared by Dr. Bhattacharyya, with cyperotundone and its derivative established the identity of both ketones, though the second and third discrepancies between their properties mentioned above have not been settled.

More recently, Nigam[5] assigned the same structure IV to the Bhattacharyya ketone for which, however, the different name cyperenone was proposed. The 2,4-dinitrophenylhydrazone of cyperenone has proved to be identical with that of Naves, Pinder, and ourselves (cyperotundone).

EXPERIMENTAL

Cyperotundone 2,4-dinitrophenylhydrazone

$C_{21}H_{26}O_4N_4$, m.p. 224–225° (uncorr), NMR ($CDCl_3$, ppm from internal TMS): doublet (3H) at 0·65 (J = 6·1 c/s, CH_3—CH<), singlet (3H) at 0·95 (CH_3—C$\lessgtr$), singlet (3H) at 1·13 (CH_3—C$\lessgtr$), broad singlet (3H) at 1·89 (CH_3—C═C). This was shown by mixed m.p. and IR comparison to be identical with the 2,4-dinitrophenylhydrazone prepared from *Cyperus scarosius* by Naves,[2] with that prepared from *C. articulatus* by Pinder,[3] and with that prepared from *C. scariosus* by Bhattacharyya.[4]

Treatment of cyperotundone 2,4-dinitrophenylhydrazone with hydrochloric acid and stannous chloride

(a) A mixture of cyperotundone 2,4-dinitrophenylhydrazone (1.62 g), $SnCl_2 \cdot 2H_2O$ (20 g), conc HCl (50 ml), H_2O (100 ml) and acetone (200 ml) was refluxed under N_2 for 2 hr. The reaction mixture was then concentrated under reduced press, diluted with H_2O, and extracted with ether. The product (0·46 g) on crystallization from light petroleum afforded cyperotundone (I) as colorless needles, m.p. 46–47·5° (uncorr), $[\alpha]_D$ +41·8° (c = 4·3, $CHCl_3$), IR (KBr) cm^{-1}: 1706, 1667 (cyclopentenone), 1412 (methylene α to carbonyl), which was identified by the usual criteria.

(b) Cyperotundone 2,4-dinitrophenylhydrazone (1·00 g) was treated by exactly the same procedure as described by Couchman *et al.*[3] to furnish the product (0·10 g) which was shown by VPC and the IR spectrum to be cyperotundone (I) alone.

Treatment of cyperotundone 2,4-dinitrophenylhydrazone with hydrochloric acid

Cyperotundone 2,4-dinitrophenylhydrazone (130 mg) in acetone (35 ml) was refluxed with conc HCl (3 ml) under N_2 for 2 hr. The mixture was concentrated under reduced press and diluted with H_2O. The recovered 2,4-dinitrophenylhydrazone (74 mg) was filtered off. The filtrate was extracted with ether affording the product (23 mg) which was shown by VPC and IR comparison to be cyperotundone (I).

Treatment of cyperotundone with hydrochloric acid and stannous chloride

A mixture of cyperotundone (50 mg), $SnCl_2 \cdot 2H_2O$ (0·5 g), conc HCl (1 ml), H_2O (2 ml) and acetone (10 ml) was refluxed under N_2 for 1 hr. Upon isolation, the product (48 mg) crystallized and was shown to be identical with the original ketone (I) (VPC and the IR spectrum).

Treatment of cyperotundone with hydrochloric acid

Cyperotundone (50 mg) and acetone (6 ml) were heated under reflux with conc HCl (0·5 ml) for 1 hr under N_2. After isolation, the product (45 mg) crystallized and was identified as the starting ketone (I) by means of VPC and IR comparison.

[5] I. C. Nigam, *J. Pharm. Sciences* **54**, 1823 (1965).

Treatment of cyperotundone 2,4-dinitrophenylhydrazone with hydrochloric acid and aluminum chloride

Cyperotundone 2,4-dinitrophenylhydrazone (175 mg), $AlCl_3$ (1.0 g), conc HCl (3 ml), H_2O (6 ml) and acetone (20 ml) were refluxed for 2 hr under N_2. The mixture was concentrated under diminished press and diluted with H_2O. The unreacted 2,4-dinitrophenylhydrazone (35 mg) was filtered off. The filtrate was extracted with ether and worked up in the usual manner to give the product (34 mg) which was shown by VPC and IR comparison to be cyperotundone (I).

Acknowledgments—We wish to thank Dr. A. R. Pinder, Clemson University, for donating the hydrazone and for discussion and Drs. Y.-R. Naves, Givaudan S. A., and S. C. Bhattacharyya, National Chemical Laboratory, for supplying the hydrazones.

ADDENDUM

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In our paper[3] on the essential oil of *Cyperus articulatus* L., we described a 2,4-dinitrophenylhydrazone, m.p. 231–232°, which we reported as being derived from the sesquiterpenoid ketone articulone, to which we have assigned structure II. It is evident, however, from direct comparisons of this derivative and cyperotundone 2,4-dinitrophenylhydrazone, made by Dr. H. Hikino (accompanying paper), Dr. I. C. Nigam,[5] and ourselves, that this product is in fact cyperotundone 2,4-dinitrophenylhydrazone, and that the essential oil of *C. articulatus* contains, in addition to articulone, cyperotundone of structure I.[1,4,5]

We also described an alcohol, articulol, in this essential oil, which we reported to be oxidized by manganese dioxide to a ketone yielding the same 2,4-dinitrophenylhydrazone. This oxidation was carried out on material purified, apparently not very successfully, by column chromatography, and it appears either that the sesquiterpene alcohol in question is cyperotundol, the alcohol corresponding to cyperotundone, or that the alcohol fraction used in the oxidation contained some cyperotundone.

We refer also to "tetrahydroarticulone", obtained by catalytic hydrogenation of articulone, which formed a 2,4-dinitrophenylhydrazone, m.p. 195–196°; this is presumably identical with dihydrocyperenone (= dihydrocyperotundone) 2,4-dinitrophenylhydrazone described by Nigam.[5] This experiment also was carried out on unpurified ketone, containing cyperotundone.

We are of the opinion that the sesquiterpene ketone fraction of the oil of *C. articulatus* does indeed contain articulone (II), but we have clearly not yet obtained this ketone, or a derivative thereof, in a pure condition.