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# A TROPONE DERIVATIVE FROM *OROBANCHE RAPUM-GENISTAE*

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**Key Word Index**—*Orobanche rapum-genistae*; Orobanchaceae; host–plant relations; 3,8-dimethyl-5-isopropyl-2,3-dihydro-(1H)azulen-6-one.

**Abstract**—A new tropone, 3,8-dimethyl-5-isopropyl-2,3-dihydro(1H)azulen-6-one, named orobanone, has been isolated for the first time from a plant (*Orobanche rapum-genistae*, Orobanchaceae). This tropone is synthetized by the parasite and exists, with other related compounds, in various species of broom-rapes.

## INTRODUCTION

During our research on the alkaloids of Orobanchaceae, parasitic phanerogames without chlorophyll [1], we observed that some compounds had a positive reaction to the Dragendorff test and most of the general tests of alkaloids. These substances were extracted with the nitrogen bases and were present both in acidic and base solutions.

We found these compounds in 12 species of broom-rapes, irrespective of the host. This preliminary work describes the structure of the most abundant product isolated from *Orobanche rapum-genistae* Thuill, to which we have given the trivial name orobanone.

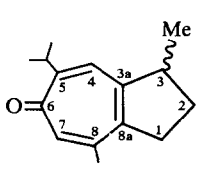
## RESULTS AND DISCUSSION

Our method for the treatment of the crude plant extract allowed the simple isolation of the orobanone, avoiding distillation, steam distillation or more complex techniques [2, 3].

A determination of the exact molecular weight by MS gave 216.1525. This value could belong to three formulae: $C_9H_{20}O_2N_4$, $C_{10}H_{20}O_3N_2$ and $C_{15}H_{20}O$. Only the last one was compatible with the $^{13}C$ NMR spectrum which showed 14 distinct signals: 185.41(*s*), 158.19(*s*), 149.78(*s*), 145.61(*s*), 144.72(*s*), 138.90(*d*), 129.78(*d*), 44.90(*d*), 34.53(*t*), 30.72(*t*), 28.81(*d*), 25.12(*q*), 22.59(*q*), 20.48(*q*). The signal at 22.59 ppm was twice as intense as those at 25.12 and 20.48 which indicated the presence of four methyl groups, two of them being isochronous. In addition, the molecule possessed seven $sp^2$ carbons, two of them (138.90 and 129.78) bearing one hydrogen. The position of the signal at 185.41, abnormal for a carbonyl group, and the high chemical shifts of the other $sp^2$ carbons led us to assign a tetrasubstituted tropone ring to orobanone [4–6].

The 250 MHz proton spectrum showed two singlets of aromatic protons at 7.093 and 6.995, the last one being broadened by a coupling with the methyl at 2.225 ($J$ = 1.0 Hz). A septet ($J$ = 6.7 Hz, 1 H) centered at 3.48 was characteristic of an isopropyl group, the two methyls of which were anisochronous (1.165 and 1.181). The spectrum showed also a broad quartet (1 H) at 3.15. Its irradiation collapsed the methyl group doublet at 1.249 ($J$ = 6.8 Hz) into a singlet. A $-CH_2-CH_2-$ group was indicated by two complex multiplets at 1.61 and 2.83 in an ABKL pattern due to the presence of an asymmetric carbon. Moreover, the methylene at 1.61 was coupled to the hydrogen whose signal was at 3.15. These observations indicated that the molecule must possess a $-CH_2-CH_2-CH(Me)-$ group whose asymmetric carbon accounted for the isopropyl methyl groups anisochrony. However, the $\Delta\delta$ was not observable in $^{13}C$ and small (0.016 ppm) in proton spectra; thus the isopropyl must be remote from the asymmetric center.

The tropone ring was therefore substituted by the chain described above, probably fixed to two adjacent carbons, by an isopropyl group and by a methyl group. The absence of any coupling between the two aromatic hydrogens indicated that they were in the 1,4 positions [7]. In nezukone [8] where the isopropyl is in position 4 of the tropone ring, the chemical shift of the isopropyl hydrogen is 2.70. In orobanone, the corresponding hydrogen had a chemical shift of 3.48. This deshielding suggested the isopropyl group was close to the carbonyl. This was corroborated by a $^1H$ NMR study with the lanthanide shift reagent Eu(fod)$_3$. The two hydrogen signals with the largest variations were the isopropyl $-CH-$ and the aromatic hydrogen coupled with an adjacent methyl group. Thus, we propose structure **1** for orobanone:




**1**

However, it is not possible to assert from our spectroscopic observations that the methyl group is at C-3 and not at C-1. We chose C-3 because of the possible sesquiterpene origin of orobanone. Moreover, the

compound isolated by Rohr *et al.* [9] has a $^{13}C$ NMR spectrum very similar to that of orobanone, differing from it only by the absence of the isopropyl group. In Tables 1 and 2 are listed the assignments for the $^{1}H$ and $^{13}C$ NMR spectra respectively. Results of Rohr *et al.* [9] are presented in Table 2 for comparison.

We searched for and found orobanone in eleven other species of broom-rapes (*O. arenaria* Borkh., *O. crenata* Forsk, *O. cruenta* Bertol., *O. epithymum* DC., *O. hederae* Duby, *O. loricata* Reichenb., *O. major* L., *O. minor* Sutt., *O. picridis* Vaucher, *O. ramosa* L., *O. variegata* Wallr.). *Orobanche rapum-genistae*, parasite of two brooms (*Cytisus scoparius* and *C. purgans*), is the species the most abundant in orobanone. On the other hand, we did not find any trace of this compound in the hosts of these broom-rapes. Thus orobanone is synthesized by the parasite and seems to be specific of these Orobanchae.

Table 1. $^{1}H$ NMR spectrum of orobanone. First-order chemical shifts and coupling constants

| | |
|---|---|
| $CH_2$-1 | 2.83* |
| $CH_2$-2 | 1.61* |
| H-3 | 3.15† |
| Me-3 | 1.249† |
| H-4 | 7.093 |
| H-(isopropyl-5) | 3.48‡ |
| Me-(isopropyl-5) | 1.165 and 1.181‡ |
| H-7 | 6.995§ |
| Me-8 | 2.225§ |

* First-order analysis of these multiplets is not possible at 250 MHz.
† $J_{Me-3/H-3} = 6.8$ Hz.
‡ $J_{Me/H} = 6.7$ Hz.
§ $J_{Me-8/H-7} = 1.0$ Hz.

Table 2. $^{13}C$ NMR chemical shifts of orobanone*,† and 3,8-dimethyl-2,3-dihydro-(1H)azulen-6-one‡

| | * | ‡ |
|---|---|---|
| C-1 | 34.53 (131) | 35.09§ |
| C-2 | 30.72 (127) | 30.51§ |
| C-3 | 44.90 (131) | 44.28 |
| C-3a | 145.61‖ | 146.06§ |
| C-4 | 129.78 (147) | 133.87§ |
| C-5 | 158.19 | 140.28§ |
| C-6 | 185.41 | 186.46 |
| C-7 | 138.90 (154) | 139.34§ |
| C-8 | 149.78‖ | 150.46§ |
| C-8a | 144.72‖ | 148.09§ |
| C(Me-3) | 25.12 (126) | 25.56§ |
| C(isopropyl) | 29.81 (127) | — |
| C(Me/isopropyl) | 22.59 (126) | — |
| C(Me-8) | 20.48 (125) | 20.15§ |

* This work.
† Values in parentheses are $^{1}J$(C-13/H-1) coupling constants.
‡ Ref. [9].
§ No assignment was made by the authors.
‖ These assignments may have to be reversed.

Whereas many tropolones (2-hydroxy-tropones) are characteristic of Cupressaceae wood [2], few tropones have been isolated from plants: nezukone [8] from a Japanese Cupressaceae, harringtonolide from a Taxaceae [5] and the one obtained by Rohr *et al.* [9] from sweet flag oil.

To our knowledge, this is the first time that orobanone has been found in a plant and that a tropone has been found in a dicotyledon.

## EXPERIMENTAL

*Extraction and purification of orobanone.* 1 kg of the whole plant, collected during flowering, air dried and powdered, was moistened with $H_2O$, introduced into a glass column (125 cm long and 6 cm internal diameter) and percolated by 15 l. $CHCl_3$. The $CHCl_3$ soln was dried over $Na_2SO_4$ and concentrated. The residue was added to 50 ml MeOH, filtered and purified with 10 g of PVP (Polyclar A.T., Serva, Heidelberg) mixed with 0.5 g of activated charcoal to eliminate the polyphenolic compounds abundant in the Orobanchae [10]. After concentration of the purified extract, the orobanone was isolated by two successive PLCs [1 mm Si gel GF (Merck 7744) eluted with cyclohexane–$CHCl_3$–MeOH, 30:65:5; MeOH was used to recover the compound from the adsorbent]. After drying under vacuum ($10^{-3}$ mm Hg over $P_2O_5$), 40 mg of a brown oil comprising a single product, orobanone, was obtained.

*TLC and spectral properties of orobanone.* The TLC analysis was performed on Si gel $GF_{254}$ (Merck 5715). The $R_f$ of orobanone was 0.66 for elution with cyclohexane–$CHCl_3$–MeOH (30:65:5) and 0.24 with $C_6H_6$–EtOAc (85:15). A modified Dragendorff test [1] or UV at 254 nm was used for detection. UV $\lambda_{max}^{CH_3OH}$ nm (log $\varepsilon$): 240 (4.03), 328 (3.65); IR $\gamma_{max}^{CHCl_3}$ cm$^{-1}$: 1610 (C=O), 1550, 1450, 1000; MS *m/e* (rel. int.): 216 (74) [$M^+$], 201 (76), 188 (23), 173 (100), 159 (25), 145 (47), 131 (51), 105 (11), 91 (23), 77 (18), 55 (14) (source temp. 50°, ionisation voltage 3.8 eV). The *m/e* was verified by CIMS. $^{1}H$ NMR spectra were recorded at 250 MHz with $CHCl_3$ solns at the Faculté de Pharmacie in Marseille. $^{13}C$ NMR spectra were obtained at the Laboratoire de Mesures Physiques of the U.S.T.L. in Montpellier on a spectrometer operating at 25.03 MHz with a digital resolution of 0.76 Hz or 0.03 ppm. Owing to the low concentration (0.06 mol/l.) of the $CDCl_3$ soln, 150 000 scans (flip angle 15°) were necessary to obtain noise decoupled spectra allowing the observation of quaternary carbon signals. For this reason, only $^{1}J(^{13}C/^{1}H)$ were measured from spectra obtained by gated decoupling. In all cases, the chemical shifts are given in ppm from the TMS signal (internal reference), and the coupling constants in Hz.

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