

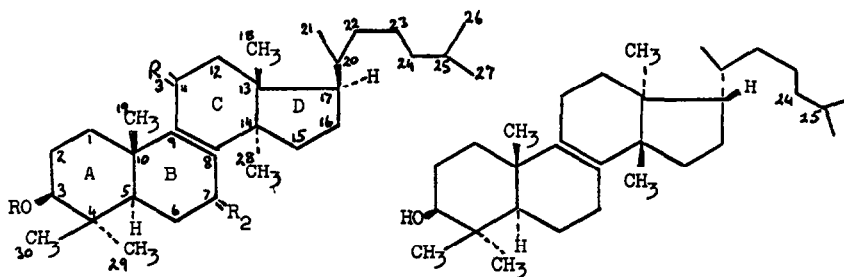
THE CARBON-13 NMR SPECTRA OF LANOSTENOL, EUPHADIENOL AND EUPHENOL

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During the past few decades a large number of compounds have been isolated from naturally occurring sources. A few of these compounds are of exceptional interest because, for example, of their key positions in biogenetic schemes (1). The tetracyclic triterpenoids lanostenol I, euphadienol IIA and euphenol IIB are of special interest because they are compounds of this type. Their structures and stereo-chemistry have already been elucidated (2), (3), (4), (5). Triterpanes and the closely related steranes have considerable chemical stability and this has led to their use as biological 'markers' in, for example, mineral oil studies (6), (7), (8). Carbon-13 NMR studies have been used in this context and as a preliminary contribution in this field the spectra given by I, IIA and IIB are described and analysed.



LANOSTENOL I

EUPHADIENOL IIA, C<sub>24</sub>=O<sub>25</sub>

IA, R=H, R<sub>2</sub>=R<sub>3</sub>=H<sub>2</sub>

IV R<sub>1</sub>=CH<sub>3</sub>CO, R<sub>2</sub>=O, R<sub>3</sub>=H<sub>2</sub>

EUPHENOL IIB, C<sub>24</sub>-C<sub>25</sub>

IB, R=CH<sub>3</sub>CO, R<sub>2</sub>=R<sub>3</sub>=H<sub>2</sub>

V R<sub>1</sub>=CH<sub>3</sub>CO, R<sub>2</sub>=H<sub>2</sub>, R<sub>3</sub>=O

III R=CH<sub>3</sub>CO, R<sub>2</sub>=R<sub>3</sub>=O

Spectra were obtained by using proton noise decoupled pulse operation. A variety of derivatives were examined as chloroform solutions. Occasionally other aromatic solvents were used to exploit specific solvent effects as an aid to band resolution. Off-resonance decoupling, chemical shift reagents and relaxation studies were also used as assignment aids.

Chemical shifts were measured from internal tetramethylsilane. Essentially identical methods were used to analyse the lanostenol and euphenol spectra. In the discussion below only the lanostenol derivatives are explicitly mentioned - a parallel series of euphenol compounds was used to obtain the euphenol spectrum assignments. The structural formulae for the compounds are given on the previous page.

A convenient starting point in the spectral assignment study was the identification of the C<sub>8</sub> side chain bands. The spectral positions of these bands were not expected to vary significantly over a set of derivatives involving only the central ring system. This invariance of spectral position and data from the earlier work of Roberts (9) on cholesterol enabled the eight carbon atoms to be identified and assigned (Table 1).

The C(3) hydroxyl carrying carbon atom and the C(8) and C(9) olefinic carbon atoms give resonances well removed from the main group of bands characterising saturate C, CH, CH<sub>2</sub> and CH<sub>3</sub> carbon atoms. Thus these three carbon atoms are easily identified and assigned.

A study of the spectra given by the 3 $\beta$  alcohol, acetate, benzoate, 3-oxo and 2 $\alpha$ -bromo-3-oxo compounds enable C(1), C(2), C(4), C(5), 4 $\alpha$  and 4 $\beta$  methyl groups - C(29), C(30) bands to be assigned (10) (11). The changes that occur on either acetylation or benzylation of the 3 $\beta$  hydroxyl group and a consideration of the steric interaction between the 4 $\beta$  and the C(10) methyl group ie C(19) indicates that the 4 $\beta$  methyl must be the highest field member of the geminal pair. A comparative study of the spectra given by the above compounds with the corresponding cholesterol derivatives (9) enables C(18) to be identified.

Off resonance noise decoupling techniques readily enable the quaternary centres at C(4), C(10), C(13) and C(14) to be identified and a preliminary assignment of these has already been reported (12). The C(4) and C(10) bands were assigned with the aid of chemical shift reagent studies. A differentiation and hence assignment of the C(13) and C(14) bands was obtained by a study of the spectrum given by 7-oxolanost-8-en 3 $\beta$ -yl acetate.

Further progress in the assignment of bands was made by considering the spectrum given by 7,11-dioxolanost-8-en 3 $\beta$ -yl acetate III. In this compound the C(7) and C(11) ketone functions and the vicinal C(6) and C(12) methylene carbon atoms give resonances that are sufficiently displaced to low field to allow the identification of the C(15), C(16), C(26) and C(19) carbon atom resonances.

A comparison of the spectrum given by III with those given by the 7-oxolanost-8-en 3 $\beta$ -yl acetate IV and 11-oxolanost-8-en 3 $\beta$ -yl acetate V enables the assignment of these C(15), C(16),

C(28) and C(19) bands to be made.

A comparative study of the spectrum given by the 11-oxo compound V with that given by III and lanostenyl acetate IB enables the bands characterising the C(6) and C(7) carbon atoms to be identified. A combination of 1-3 methyl group interactions (13) and the diamagnetic screening influence of the C(8) double bond (eg cholestene/cholestane spectra (9), lanost-8-enol/lanostanol spectra (14)) indicate that the C(6) band is to high field of the C(7) band. A similar comparative study of the 7-oxolanost-8-en  $3\beta$ -yl acetate IV, the 7,11-dioxo compound III and lanostenyl acetate IB enables the C(11) and C(12) bands to be identified and assigned.

A parallel series of experiments with a series of analogous compounds derived from euphenol (eupha-8(9)-en  $3\beta$ -ol) has enabled the carbon-13 NMR spectrum of this compound to be measured and assigned. A list of the assignments is given in Table 1. In view of influences stereochemical features can have on carbon-13 NMR spectra the small differences observed between the spectra of the two triterpenes lanostenol and euphenol are remarkable.

The spectrum of euphenol and literature reference data (16) enables the spectrum of the naturally-occurring eupha-8(9), 24(25)-diene- $3\beta$ -ol (euphadienol) to be assigned. The chemical shifts for the carbon atoms in this molecule are also given in Table 1.

At the completion of this work our attention was drawn to a letter (15) by Lukacs, Khuong-Huu, Bennett, Buckwalter and Wenkert describing an analysis of the carbon-13 lanostenol spectrum. The assignments suggested by Lukacs et al agree with the values obtained in this work for 26 of the 30 carbon atoms. The differences concern C(6), C(11), C(19), C(21). The latter is in the C<sub>8</sub> side chain and the invariance of its band position through many chemical shift reagent experiments with oxygenated ring derivatives and a consideration of the spectra of these derivatives themselves indicates that the 4th band in the lanostenol spectrum (from TMS) must be given by C(21) and not C(19). The C(19) band can be identified by tracking its small shifts through the compound series mentioned in this work. The ordering of C(6) and C(11) comes from a similar study.

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## REFERENCES

- (1) T.T. Chen and K. Bloch, *J. Amer. Chem. Soc.*, **77**, 6085, (1955).
- (2) W. Voser, Hs. H. Gunthard, H. Heusser, O. Jeger and L. Ruzicka, *Helv. Chim. Acta.*, **35**, 2065, (1952).
- (3) C.S. Barnes, D.H.R. Barton, A.R.H. Cole, J.S. Fawcett and B.R. Thomas, *Chem. and Ind.*, 426, (1952).
- (4) D.H.R. Barton, J.F. McGhie, M.K. Pradhan and S.A. Knight, *J. Chem. Soc.*, 876, (1955).
- (5) K. Christen, M. Dennenberger, C.B. Roth, H. Heusser and O. Jeger, *Helv. Chim. Acta.*, **35**, 1756, (1952).
- (6) I.R. Hills, G.W. Smith and E.V. Whitehead, *Nature*, **219**, 243-6, (1968).
- (7) I.R. Hills, G.W. Smith and E.V. Whitehead, *J. Inst. Pet.*, **56**, 127, (1968).
- (8) B. Balogh, D.M. Wilson and A.L. Burlingame, *Nature*, **233**, 261, (1971).
- (9) H.J. Reich, M. Jautelat, M.T. Messe, F.J. Weigert and J.D. Roberts, *J. Amer. Chem. Soc.*, **91**, 7445, (1969).
- (10) J.D. Roberts, F.J. Weigert, J.I. Kroshwitz and H.J. Reich, *J. Amer. Chem. Soc.*, **92**, 1338, (1970).
- (11) F.J. Weigert and J.D. Roberts, *J. Amer. Chem. Soc.*, **92**, 1347, (1970).
- (12) S.A. Knight, DGMK Meeting, Munster, West Germany, September 1971; *Erdöl und Kohle*, September 1972.
- (13) D.K. Dalling and D.M. Grant, *J. Amer. Chem.*, **89**, 6612, (1967).
- (14) S.A. Knight, unpublished work.
- (15) G. Lukacs, F. Khuong-Huu, C.R. Bennett, B.L. Buckwalter and E. Wenkert, *Tetrahedron Letters* 1972, 3515.
- (16) M. Jautelat, J.B. Grutzer and J.D. Roberts, *Proc. Nat. Acad. Sci.*, **65**, 288, (1970).

TABLE 1

TABLE OF CARBON-13 CHEMICAL SHIFTS ( $\text{CHCl}_3$  SOLUTIONS)  
(parts per million from internal tetramethylsilane)

C No.	Lanostenol	Euphenol	Euphadienol	C. No.	Lanostenol	Euphenol	Euphadienol
1	35.8	35.4	35.3	16	31.0	29.8	29.8
2	27.9	27.8	27.7	17	51.2	49.8	49.6
3	79.0	78.9	78.7	18	15.9	15.7	15.6
4	39.0	37.3	38.9	19	18.3	20.2	20.1
5	50.5	51.1	51.0	20	36.5	35.7	35.3
6	19.2	19.1	18.9	21	18.8	19.1	18.9
7	28.3	28.0	27.9	22	36.5	36.1	35.9
8	135.1	134.1	134.1	23	24.2	23.9	24.7
9	135.1	133.6	133.5	24	39.6	39.5	125.3
10	37.2	39.0	37.2	25	28.1	28.0	130.5
11	21.1	21.6	21.5	26	22.6	22.8	17.6
12	26.7	28.1	28.1	27	22.8	22.8	25.7
13	44.6	44.2	44.1	28	24.3	24.5	24.5
14	49.9	50.1	50.0	29	28.1	28.0	28.1
15	31.2	31.0	30.9	30	15.4	15.5	15.6