

APPLICATION OF HOMONUCLEAR INDOR TECHNIQUE. STRUCTURE OF
AN ACID-INDUCED REARRANGEMENT PRODUCT OF 16-KETO-FRIEDEL-3-ENE

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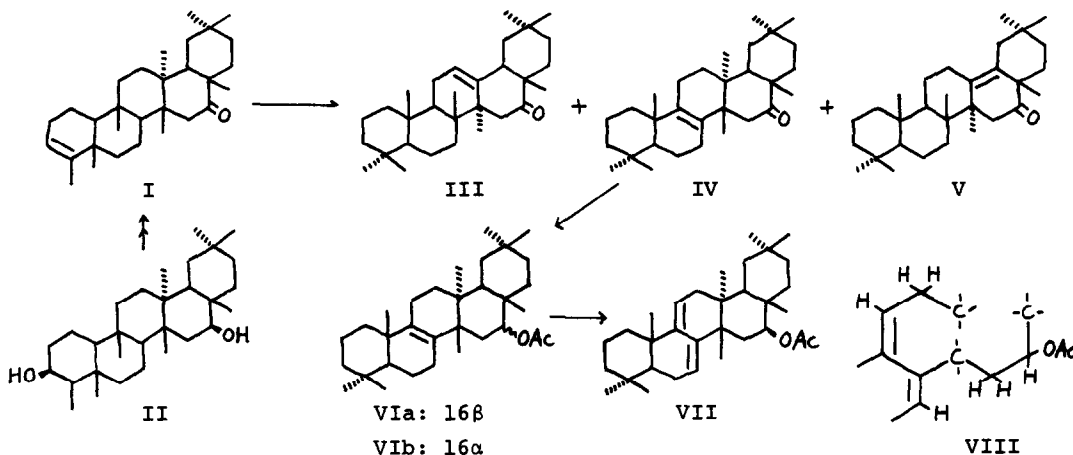
In previous papers,¹⁾ we reported that the reaction of 16-keto-friedel-3-ene (I), derived from pachysandiol-B (II), with $ZnCl_2$ in acetic acid gave 16-keto-olean-12-ene (III) and two unidentified products B (IV) and C (V). Now the structure of product-B has been assigned to the formula IV by the chemical and spectroscopic analyses, especially by the application of homonuclear INDOR technique which was first described by Baker.²⁾

Product-B (IV), mp 218-221°, $C_{30}H_{48}O$, shows a carbonyl band at 1680 cm^{-1} in the IR spectrum and no olefinic proton signal in the NMR spectrum. Reaction of IV with $LiAlH_4$, followed by acetylation, gave an acetate (VIa), mp 182-185°, and its epimer (VIb), mp 189-192°, in a ratio of about 1 : 2. Both VIa and VIb regenerated IV upon CrO_3 oxidation after alkaline hydrolysis.

In the NMR spectra, VIa shows the signal of 16-proton at δ 5.27 as a triplet ($J=9$ Hz), while VIb at δ 5.18 as a quartet ($J=6.5, 10.5$ Hz), indicating that their acetoxy groups are both equatorial. The configuration of their 16-acetoxy groups was determined to be β in VIa and α in VIb by comparison of the chemical shifts and splitting patterns of 16-hydrogens with those of 16 β - and 16 α -acetoxyfriedelane.^{1,3)}

Treatment of VIa with SeO_2 gave a diene (VII), $C_{32}H_{50}O_2$, λ_{max}^{EtOH} nm: 235 (sh.), 241 (ϵ 11030), 248 (sh.) (heteroannular conj. diene), whereas the same reaction of VIb resulted in recovery of the starting material.

Then we performed the INDOR experiment³⁾ of acetate VIb in which the D ring is in chair form. As illustrated in Fig. 1, monitoring the quartet lines of 16-H gave INDOR signals arising from 15- H_2 at δ 1.4-1.8 region and a small peak



at δ 1.08. The latter peak could be ascribed to the so-called NOE due to the 26- and 28-CH₃ groups, since irradiation at δ 1.08 gave a 24% NOE increment in the 16-H signal.

In the presence of a lanthanide shift reagent (Eu(DPM)₃, 0.15 mol.equiv.),⁴⁾

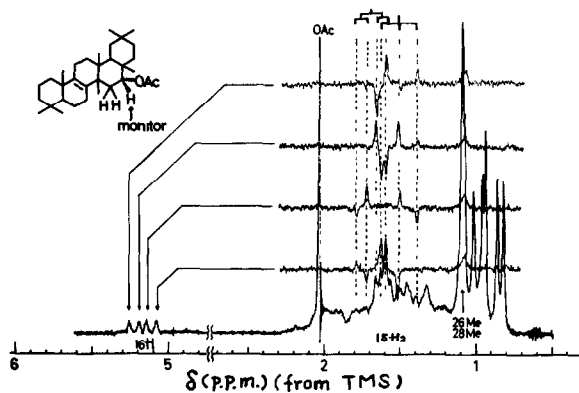


Fig. 2 100 MHz spectrum of VIb with Eu(DPM)₃ added and INDORE spectra

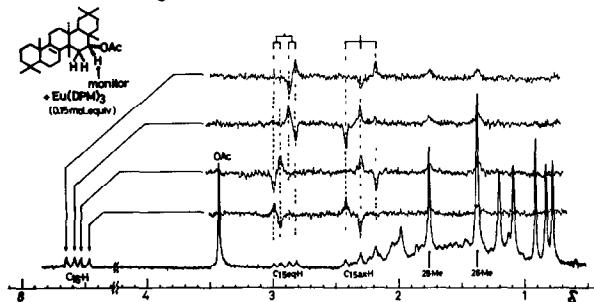
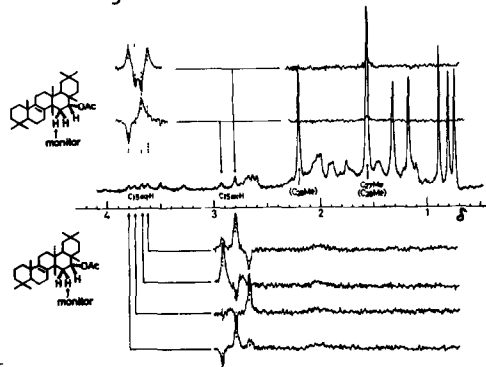


Fig. 1
100 MHz normal and INDORE spectra of VIb.

Fig. 3
100 MHz spectrum of VIb with Eu(DPM)₃ added and INDORE spectra.



the INDOR signal and the NOE peaks are more clearly resolved as shown in Fig. 2, in which the peaks at δ 1.37 and 1.75 are ascribed to the NOE due to the 28- and 26-CH₃, respectively, based on their shift values. Using the two lines of 15(ax)-H as monitor lines at a molar ratio 0.25 : 1 of Eu(DPM)₃ to substrate, INDOR signals of 15(eq)-H were observed at δ 3.70 and at the same time an NOE peak appeared at the CH₃ signal position of δ 1.56,⁵⁾ which is assignable to the 27-CH₃ group (Fig. 3). In turn, irradiation at δ 1.56 gave an about 5% NOE increment in the 15(ax)-H signal. Next, monitoring the quartet of 15(eq)-H gave INDOR signals for 15(ax)-H around δ 2.68-2.93 and a broad NOE peak at δ 2.06⁶⁾ (Fig. 3). The latter peak would be ascribed to the NOE due to 7 α -H. Unfortunately, however, more detailed information could not be obtained.

Next we carried out the INDOR experiments with the diene acetate (VII). The NMR spectrum of VII shows broad signals at δ 5.23 and 5.57 for two olefinic protons and a triplet ($J=9$ Hz) at δ 5.18 for the 16-H geminal to the acetoxy group, suggesting a boat conformation of the D-ring. Monitoring the triplet lines of 16-H led us to find the signals of 15(eq)-H and 15(ax)-H (see Fig. 4). In this case, a small NOE peak was also observed at the CH₃ signal position of δ 0.86, which may be ascribed to the 27-CH₃. When the lines of 15(eq)-H were monitored, an NOE peak appeared at the position of lower lying olefinic signal at δ 5.57 (Fig. 4). Moreover, irradiation at the 15(eq)-H gave a 9.5% incre-

Fig. 4 100 MHz normal and INDOR spectra of VII.

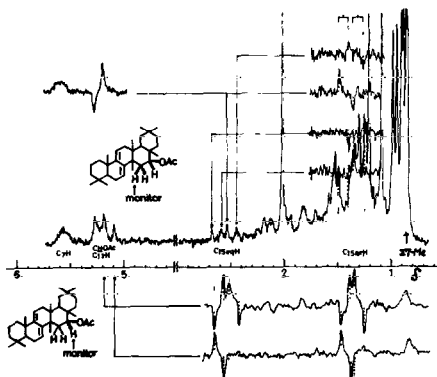
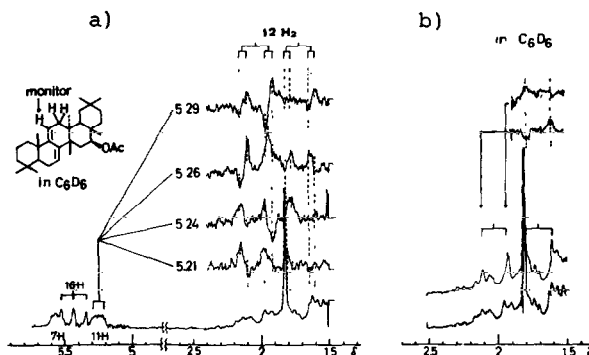


Fig. 5 100 MHz normal, double resonance, and INDOR spectra of VII in C₆D₆.



ment of the signal intensity of the above olefinic proton and, in turn, irradiation at the latter signal gave a 7% NOE increment in the former. Accordingly, this olefinic hydrogen can be reasonably assigned to the 7-H and therefore the $\Delta^{7,9(11)}$ -diene structure (VII) was suggested for this compound.

The signal of another olefinic proton (δ 5.25) in CDCl_3 is overlapping with that of 16-H. In C_6D_6 , however, they are resolved and the olefinic proton signal appears at δ 5.25 as a broad peak. The INDOR experiment using this broad signal as monitor line disclosed two sets of quartet for methylene hydrogens (Fig. 5a). Decoupling of the olefinic proton by irradiation at δ 5.25 simplified the spectrum, in which the methylene signal appeared as an AB quartet (δ 1.67 and 2.01, $J=18$ Hz) partially overlapped with other signals as shown in Fig. 5b. Monitoring now the two lines of this AB quartet confirmed the position of the other two lines (Fig. 5b). Thus, the presence of a partial structure VIII in the diene acetate (VII) was established.

On the basis of forgoing findings, the structure of the diene acetate can be assigned to the formula VII, and hence the rearrangement product-B to the formula IV.

REFERENCES and FOOTNOTES

- 1) T. Kikuchi, M. Takayama, T. Toyoda, M. Arimoto, and M. Niwa, Tetrahedron Letters, 1535 (1971); Idem, Chem. Pharm. Bull. (Tokyo), in press.
- 2) E. B. Baker, J. Chem. Phys., 37, 911 (1962).
- 3) NMR and INDOR spectra were measured in CDCl_3 unless otherwise noted, using a Varian HA-100D Spectrometer which was modified for INDOR experiments according to the report by Jenkins et al. See P. N. Jenkins and L. Phillips, J. Phys. (E), 4, 530 (1970).
- 4) R. von Ammon and R. D. Fischer, Angew. Chem., 84, 737 (1972).
- 5) On addition of some more $\text{Eu}(\text{DPM})_3$, this signal was separated into two singlets. At this stage, the INDOR experiment using the lines of 15(ax)-H as monitor lines gave an NOE peak at the lower-side singlet. Therefore, the latter singlet was assigned to the 27- CH_3 group.
- 6) Irradiation at δ 2.06 gave an 11% NOE increment in the 15(eq)-H signal.