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METHYLENE PROTON NON-EQUIVALENCE IN CARBOETHOXY GROUPS DUE TO LONG-RANGE ASYMMETRY EFFECTS IN A SPIROCYCLOPROPANE

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The magnetic non-equivalence of methylene protons in ethyl groups has been demonstrated for ethers (2-4), sulfites (5), sulfoxides (6,7), ortho- and meta-substituted N,N-dimethylbenzylamines (8), esters of α-hydroxy acids (9,10), and has been the subject of a recent review (11).

Although certain examples of this magnetic non-equivalence were temperature dependent and resulted from differences in conformational population, other temperature independent examples have been attributed to the asymmetric environment of the methylene protons caused by a lack of molecular symmetry (7).

We presently report and show that this latter type of non-equivalence is induced in 1,2-dicarboethoxycyclopropanes when an asymmetric ring system is attached spiro at the 3- position of the cyclopropane ring.

As a result of the different orientation of the carboethoxy groups with respect to the naphthalenone ring, trans-2,3-dicarboethoxy-2'-methylspiro[cyclopropane-1,4'-(1'-naphthalenone)] I (Fig. 1) would be expected to exhibit two magnetically non-equivalent methylene groups. The non-equivalent methylene quartets, however, did not appear as single quartets but showed a doubling. This extra splitting on each quartet was not attributable to spin-spin coupling with the cyclopropyl protons as the AB quartet (ν_A = 3.523 ppm, ν_B = 3.205 ppm, J_{AB} = 7.62 Hz)

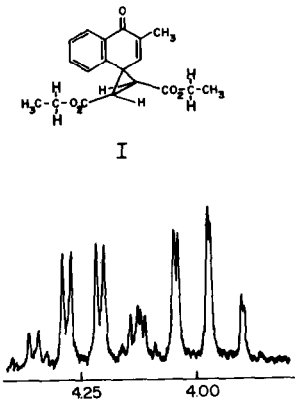


Figure 1. Methylene proton region in the NMR spectrum of I (100MHz,$CDCl_3$). The scale is in ppm, zero at TMS.

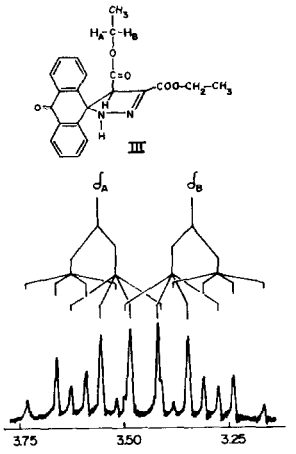
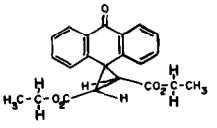


Figure 2. Methylene proton region in the NMR spectrum of II (100MHz,$CDCl_3$). The scale is in ppm, zero at TMS.

arising from these protons was visible to higher field and showed no evidence of this separation. When the spectrum was obtained in C_5D_5N, the separation was smaller (12) and independent of temperature changes over the range 30-110°.

Our interpretation of these extra splittings is that due to the asymmetry of the spiro-naphthalenone ring, the two methylene protons of each methylene group are non-equivalent and therefore couple each other ($J_{AB} \sim 10.8$ Hz) as well as the adjacent methyl groups ($J_{A(B),CH_3}$ = 7.1 hz). The chemical shift difference, $\Delta\nu_{AB}$, is small, however, and thus the outer members of the eight AB quartets are, for the most part, too small to be seen.

Since the non-equivalence was not temperature dependent, we attribute the effect to induced asymmetry from the spiro-naphthalenone ring rather than to restricted rotation or conformational changes. In support of this conclusion, the methylene proton non-equivalence was lost



when the asymmetrical naphthalenone ring in I was replaced with a symmetrical anthrone ring in

trans-2,'3'-dicarboethoxyspiro[anthrone-10,1'-cyclopropane] II. In this latter compound the ethyl groups appeared as a normal A_3X_2 spin pattern.

It may be interesting to point out another case of methylene proton non-equivalence in one of the carboethoxy groups in a precursor of II, 2-pyrazoline III (Fig. 2).

In this case, one methylene group appeared as a normal quartet ($J_{CH_2CH_3}$ = 7.1 Hz) while the other methylene group appeared as four overlapping AB quartets from 3.168 to 3.735 ppm. This extra coupling does not arise from spin-spin coupling with either of the protons on the ring carbon or nitrogen as they were observable at 4.125 and 7.252 ppm respectively as singlets.

Significantly, in III where one of the carboethoxy groups is not bonded to an asymmetric ring carbon, a normal A_3X_2 spin pattern resulted. The other carboethoxy group, however, is bonded to an asymmetric carbon and the methylene group in this case has non-equivalent protons, coupled to each other (JAB = 10.6 Hz) as well as to the adjacent methyl protons ($J_{A(B),CH_3}$ = 7.1 Hz). Conformational effects cannot be ruled out in this case, however, since temperature dependence experiments were precluded by the heat lability of pyrozoline III.

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