

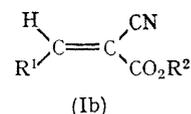
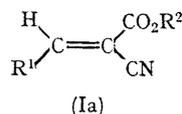
The Stereochemistry of Alkylidenecyanoacetic Acids and Esters

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RECENTLY, Jakobsen *et al.*¹ reported that ethyl ethylidene-cyanoacetate (I; R¹ = Me, R² = Et), prepared by the Knoevenagel condensation of acetaldehyde and ethyl cyanoacetate,² is a single geometrical isomer [(Ia) or (Ib)]. On the basis of the following evidence. (i) The n.m.r. spectrum showed only one Me doublet and only one quartet for the ethylenic proton, and (ii), the finding of Hayashi and his co-workers³ that the resonance positions for the β -methyl protons in β -alkyloxy- α -cyano- β -methylacrylic esters are different, depending on whether the methyl group is *cis* or *trans* to the ester group. Jakobsen *et al.*¹ were unable to conclude, however, which of the two isomers they had obtained.

We have prepared propylidene-cyanoacetic acid⁴ (I; R¹ = Et, R² = H) and its methyl ester,² (I; R¹ = Et,



R² = Me) and found that the n.m.r. spectrum of the ester (see Table) is entirely consistent with the spectrum of the lower homologue reported by Jakobsen *et al.*¹ All the propylidene hydrogen absorptions appeared as sharply defined multiplets, as would be predicted for a single isomer

Chemical shifts (δ)^a

| | -Me | -CH ₂ - | =CH- | $\begin{array}{c} \text{O} \\ \parallel \\ \text{-C-OMe} \end{array}$ | -CO ₂ H |
|---------------------------------------------------------|---------------------------------------------|---------------------|-----------|-----------------------------------------------------------------------|--------------------|
| EtHC=C(CN)·CO ₂ Me ^b | 1.185 (t) | 2.585 (quintet) | 7.645 (t) | 3.84 (s) | |
| Et ₂ C=C(CN)·CO ₂ Me ^b | 1.20 (t) ^d 1.12 (t) ^d | 2.56 (q) 2.77 (q) | | 3.78 (s) | |
| Et ₂ C=C(CN) ₂ ^b | 1.21 (t) | 2.59 (q) | | | |
| EtHC=C(CN)·CO ₂ H ^c | 1.21 (t) | 2.63 (quintet) | 7.78 (t) | | 11.25 (s) |
| Et ₂ C=C(CN)·CO ₂ H ^c | 1.23 (t) ^d 1.15 (t) ^d | 2.635 (q) 2.825 (q) | | | 11.30 (s) |

^a In p.p.m. from Me₄Si, recorded on a Varian HA-100 spectrometer; ^b 20% w v in CCl₄; ^c 20% w v in CDCl₃; ^d Overlapping triplets

by first-order analysis. Also, the nature of the propylidene hydrogen absorptions in the n.m.r. spectrum of the propylidenecyanoacetic acid was similar to that in the ester, indicating that the acid was a single isomer and that it had the same configuration. When these spectra (Table) were compared with those of methyl (1-ethylpropylidene)cyanacetate,⁵ the corresponding acid, and (1-ethylpropylidene)malononitrile,⁶ all five compounds were found to have methyl absorptions at δ 1.21 \pm 0.02 p.p.m., and methylene absorptions at δ = 2.60 \pm 0.04 p.p.m., indicating that the absorptions must be associated with the ethyl group *cis* to the cyano-group. Thus, the stereochemistry of (I; R¹ = Et, R² = Me and H) is established as (Ia). It would appear reasonable to assign the same stereochemistry to other alkylidenecyanoacetates obtained by the Knoevenagel condensation. The =CH- groups in butylidenecyanoacetic acid and its methyl ester have the same chemical shift as in the other compounds. Also, all the multiplets are undoubled.

The positions of the CH₂-absorption can be correlated

with the assignments made by Hayashi *et al.*³ for the stereochemistry of β -alkoxy- β -alkyl- α -cyano-acrylates. These authors, citing precedents of other $\alpha\beta$ -unsaturated esters, based their structural assignments on the assumption that the protons on the β -carbons are more deshielded when they are *cis* to the ester group than when they are *trans*. This assumption we found was true. Conversely, the γ -Me protons were more shielded when *cis* to the ester group, which was the case for the esters studied by the Japanese workers.

A reasonable explanation for our findings would be that the stereochemistry of these Knoevenagel condensation products is most probably controlled by the relative sizes of the cyano- and the carboxylic acid or ester groups. The cyano-group, since it is the smallest, would interact least with the β -alkyl group. It will be of interest to see whether the stereochemistry is altered by changing either the reaction conditions (we used a bifunctional catalysis) or the bulk and the electronic nature of the aldehyde reactant.

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