

## Isomerisation of $\beta$ - to $\alpha$ -Pyrrolenines

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*Summary* Quantitative conversion of several novel  $\beta$ -pyrrolenines into the  $\alpha$ -isomers proceed *via* a Wagner-Meerwein type of rearrangement.

FOLLOWING our report<sup>1</sup> of the first preparation and characterization of some simple  $\beta$ -pyrrolenines (I) together with their  $\alpha$ -isomers (II), we have found that (Ia—d) undergo an unusual isomerization to the corresponding  $\alpha$ -isomers (IIa—d) under a variety of conditions. The conversion is unidirectional and usually quantitative, hence synthetically useful and theoretically interesting. We report the gener-

ality as well as the kinetic and mechanistic aspects of this isomerization.

The rearrangement was first studied in decalin under reflux in the dark under a nitrogen atmosphere. The reaction mixtures were analysed by g.l.c.† using conditions previously established for the separation of the pyrrolenine isomers and the parent pyrrole. The structural assignment of the  $\alpha$ -products were further confirmed by isolation and spectral characterizations as described earlier.<sup>1</sup> The  $\beta$ -ethyl group in (Ib—d) migrated exclusively. In no cases were pyrroles or other isomeric  $\beta$ -pyrrolenines or extraneous

† Refer to footnotes in ref. 1.

peaks detected on the gas chromatogram. There was also no sign of an equilibrium between the  $\beta$ - and  $\alpha$ -pyrrolenines and under no circumstances was the reverse rearrangement of (II) to (I) observed. Since the isomerization of (Id) to (IId) proceeded with the trideuteriomethyl group intact at the  $\beta$ -position, a ring skeletal rearrangement is disallowed. Thus, the conversion of  $\beta$ - into  $\alpha$ -pyrrolenines must involve a simple alkyl migration.

The pentamethylpyrrolenine (Ia) was chosen for the mechanistic study. The reaction, followed by glc,<sup>†</sup> was first order in (Ia) in all the media used. Thus, the isomerization of a 0.1M-solution of (Ia) in bis-( $\beta$ -ethoxyethyl) ether to (IIa) took place cleanly at 189° (half-life 11 h). The rate constant was not noticeably affected at 10 fold dilution or upon addition of 0.1 equivalent of benzoyl peroxide or hydroquinone. It appears that the alkyl migration may be intramolecular and that the reaction does not involve any radical species. The reported<sup>2</sup> thermal isomerization of 1,2,4,5,5-pentamethylcyclopentadiene to 1,2,3,4,5-pentamethylcyclopentadiene at ca 500 °C proceeds *via* successive 1,5-sigmatropic alkyl shifts. However, the  $\beta$ -pyrrolenines or 2-azacyclopentadienes rearranged to the  $\alpha$ - or 1-aza-isomers under much milder conditions, and the specificity of the alkyl shift is incompatible with a sigmatropic reaction which would lead to eventual alkyl scrambling. This conclusion is corroborated by the rate dependence of (Ia) on medium effects. In ethanol, the increasing polarization of the imino-bond in (Ia) due to hydrogen bonding with the solvent resulted in significant rate enhancement, thus implicating a Wagner-Meerwein type of rearrangement. Confirmation was sought in acid catalysis where the presence of one equivalent of toluene-*p*-sulphonic acid increased the rate constant many times. In the Table

Isomerization of (Ia) to (IIa)<sup>a</sup>

Systems	$k$ (25 °C) (s <sup>-1</sup> )	$\Delta H^\ddagger$ (kcal mol <sup>-1</sup> )	$\Delta S^\ddagger$ (e u)
(Ia)-(EtOCH <sub>2</sub> CH <sub>2</sub> ) <sub>2</sub> O	$1.66 \pm 0.09 \times 10^{-15}$	37.5	-0.5
(Ia)-EtOH	$5.20 \pm 0.07 \times 10^{-12}$	27.7	-17.4
(Ia <i>p</i> -TsOH)-EtOH	$1.35 \pm 0.17 \times 10^{-7}$	24.1	-9.1

<sup>a</sup> The Arrhenius plot data were fitted to a polynomial equation of degree 1, and the calculations of  $k$ ,  $\Delta H^\ddagger$ , and  $\Delta S^\ddagger$  at 25 °C were performed on an IBM 360/40 computer using a program of statistical routines, correlation coefficients > 0.990.

<sup>1</sup> J. L. Wong and M. H. Ritchie, *Chem. Comm.*, 1970, 142.

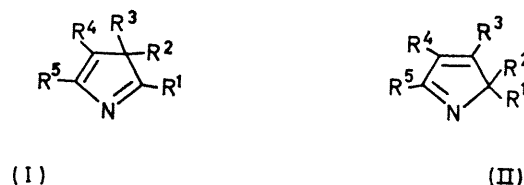
<sup>2</sup> V. A. Mironov, V. S. Pashegorova, T. M. Fadeeva and A. A. Akhrem, *Tetrahedron Letters*, 1968, 3997.

<sup>3</sup> W. E. McEwen, D. H. Berkebile, T. K. Liao, Y. S. Lin, *J. Org. Chem.*, 1971, **36**, 1459; W. E. McEwen, T. T. Yee, T. K. Liao, and A. P. Wolf, *ibid.*, 1967, **32**, 1947.

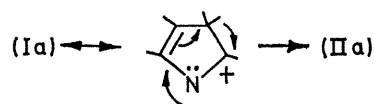
<sup>4</sup> Y. Kanaoka, K. Miyashita, and O. Yonemitsu, *Tetrahedron*, 1969, **25**, 2757.

<sup>5</sup> H. Booth, A. W. Johnson, E. Markham, and R. Price, *J. Chem. Soc.*, 1959, 1587; H. Booth, A. W. Johnson, F. Johnson, and R. F. Langdale-Smith, *ibid.*, 1963, 650.

these rate constants calculated at 25 °C and the concomitant activation energies are compared. These reaction characteristics are totally compatible with an alkyl migration from carbon to an adjacent cationoid centre as shown in the Scheme. Certain aspects of this isomerization



- a, R<sup>1</sup>=R<sup>2</sup>=R<sup>3</sup>=R<sup>4</sup>=R<sup>5</sup>=Me  
 b, R<sup>1</sup>=R<sup>3</sup>=R<sup>4</sup>=R<sup>5</sup>=Me, R<sup>2</sup>=Et  
 c, R<sup>1</sup>=R<sup>3</sup>=R<sup>4</sup>=Me, R<sup>2</sup>=Et, R<sup>5</sup>=H  
 d, R<sup>1</sup>=R<sup>4</sup>=Me, R<sup>2</sup>=Et, R<sup>3</sup>=CD<sub>3</sub>, R<sup>5</sup>=H



SCHEME

are analogous to the acid-catalysed reaction of 2-(1-isoquinolyl)-3,5,5-triphenylpyrrolenine<sup>3</sup> to form a pyrrole and the alkyl scrambling of  $\beta$ -indolenines in acid.<sup>4</sup> That the unique specificity of the rearrangement of (I) to (II) is not steric in origin is shown by the quantitative conversion of the *N*-methyl perchlorate salt of (Ia) into the *N*-methyl salt of (IIa) upon gentle heating. No reverse reaction could be effected.

This isomerization partially rationalizes the absence of  $\beta$ -pyrrolenines in the alkylation of *C*-alkylpyrrole Grignard derivatives reported earlier. The alkylated products were often treated with *HN*-acid during the work-up. We have found that the half-life of the (Ia) into (IIa) conversion in *HN*-aqueous hydrochloric acid at room temperature is 7.28 h, and the isomerization of (Ic) is even faster under similar conditions.

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