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Determination of a Low Isomerisation Barrier in a Push-Pull Alkene: Conversion of the (*Z*)-Isomer to the (*E*) 1-Methyl-4-(2'-methylthiovinyl)-pyridinium Iodide.

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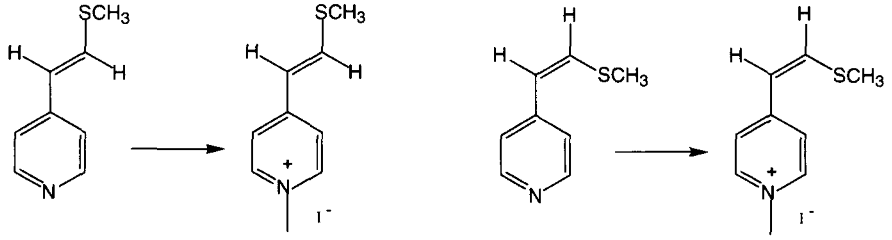
Abstract: The (*Z*)-1-methyl-4-(2'-methylthiovinyl)-pyridinium iodide **4** was prepared from the corresponding pyridine under conditions where the salt **4** was precipitated before undergoing the irreversible isomerisation to (*E*) isomer **3**. The kinetics of the isomerisation of (*Z*) isomer **4** to (*E*) **3** was studied by ^{1}H-NMR. The activation parameters were calculated from the Eyring equation and found to be $\Delta H^{\neq}$ +14 kcal mol^{-1} (59 kJ mol^{-1}) and $\Delta S^{\neq}$ -26 eu (- 108 Jmol^{-1}K^{-1}). This is certainly one of the lowest barriers to an irreversible isomerisation which has been determined.

The Wittig reaction of the ylide derived from methylthiomethyltriphenylphosphonium chloride [1] with isonicotinaldehyde gave a mixture of (*E*) and (*Z*) isomers of 4(2'-methylthiovinyl) pyridine **1** and **2** in a yield of 87% (ratio of 9/1). These isomers could be separated by chromatography on silicagel treated with triethylamine, they were stable at 0°C and their stereochemistry was assigned by ^{1}H-NMR (vinylic coupling constants of 15.5 Hz for the (*E*) isomer **1** and of 11 Hz for the (*Z*) isomer **2**).

On quaternisation at the nitrogen atom of both isomers **1** and **2** with *p*-chlorobenzyl chloride, ethyl bromide and methyl iodide the (*E*) isomer gave the (*E*) pyridinium salt, but the (*Z*) isomer gave at best a mixture of the (*E*) and (*Z*) pyridinium salt. On purification of this mixture by recrystallization, only the (*E*) isomer could be obtained. Examination of the mother liquors showed the presence of the (*E*) salt only. Based on these observations, it was concluded that the (*Z*) isomer had been converted to the (*E*) isomer under these conditions.



1 **3** **2** **4**

If the quaternisation of the (*Z*) isomer **2** with methyl iodide was run at 20°C in ether where both reagents were soluble, the (*Z*) pyridinium salt **4** precipitated with a yield of 43%. The analytical data corresponded to the formula and when the ^{1}H NMR spectral data were determined very shortly after preparing the solution, the spectrum corresponded to the (*Z*) isomer **4** (vinylic coupling: 11Hz). On standing the conversion of the (*Z*) isomer **4** to the (*E*) isomer **3** was observed. Furthermore, on longer reaction time only the (*E*) isomer **3** was obtained. So the isomerisation was irreversible. The absorption data of both salts were different : in methanol the (*E*) **3** isomer showed an absorption of 34100 $M^{-1}cm^{-1}$at 362 nm and the (*Z*) isomer **4** of 22500 $M^{-1}cm^{-1}$ at 368 nm.

The isomerisation rate of (*Z*) isomer **4** to the (*E*) isomer **3** was studied at 300°, 310° and 320 °K by ^{1}H-NMR in DMSO-$^{2}H_{6}$. The signals corresponding to the vinylic proton next to the sulfur were used to monitor the reaction (δ = 7.51 ppm in the (*Z*) **4** and 8.23 ppm in the (*E*) isomer **3**). The concentration of the salt **4** was 26 mM except at 300°K where the concentration was 26 mM and 13 mM. The isomerisation obeyed first order kinetics and the rate constants were at 300°K 0.80 10^{-4} sec^{-1}, at 310°K 1.8 10^{-3} $sec^{-1}$and at 320°K 3.6 10^{-3} sec^{-1} (correlation factors[2] ranging from 0.979 to 0.998). The activation parameters were calculated from the Eyring equation[2] and found to be $\Delta H^{\neq}$ +14 kcal mol^{-1} (59 kJ mol^{-1}) and $\Delta S^{\neq}$ -26 eu (- 108 $Jmol^{-1}K^{-1}$). From these data the half life at 300°K was calculated to be about 800 sec. This is certainly one of the lowest isomerisation barriers which has been determined.

This kinetic study was possible because the reaction of the pyridine to the pyridinium salt was a clean reaction. Indeed, the pyridinium salt **4** has a very low solubility in the reaction medium, precipitated and in the solid state the isomerisation did not occur. So all conditions were met to obtain the unstable pyridinium salt **4**.

The pyridinium salts **3** and **4** are push-pull alkenes:[3,4] on one side at the pyridinium is an electron attracting group and on the other side the thioether is the electron releasing group. The low barrier to isomerisation may reflect contributions by the anhydrobase resonance canonical depicted in figure **1**.

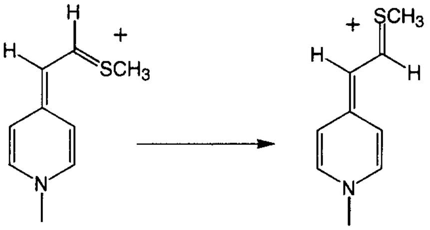


Figure 1

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