HOMOLYTIC ADDITION OF 1-ALKANETHIOLS TO 5-ETHYNYL-2-METHYLPYRIDINE

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The homolytic addition of 1-butane- and 1-heptanethiol to 5-ethynyl-2-methylpyridine has been studied. Products of mono- or di-addition can be obtained by varying the reaction conditions.

Addition of alkanethiols to pyridylacetylene has been little studied [1]. It seemed interesting to study the homolytic addition of alkanethiols to the C=CH of pyridylacetylene, to examine its selectivity and to establish the factors which influence the course of the reaction. 1-Butane- (Ia) and 1-heptanethiol (Ib) were chosen as the source of the thiyl radicals. We studied in detail and in various conditions the reaction of thiol Ia with 5-ethynyl-2-methylpyridine (II) in the presence of di-tert-butyl peroxide or benzoyl peroxide. At 140°C with a 10-fold excess of thiol the process did not stop at the mono-addition stage but continued further as in the scheme below:

Under the above conditions the isomeric 5-(2-butylthioethenyl)-2-methylpyridines (IIla,b) are formed in no more than 20% yield, because they readily react with second molecule of thiol to give 5-[1,2-di(butylthio)ethyl]-2-methylpyridine (IV) in a yield up to 70%. Decreasing the temperature and decreasing the excess of thiol reduces the formation of 1:2 adduct. For example at 100-110°C (5 h) and ratio of Ia:II:benzoyl peroxide 1.5 : 1 : 0.015 the vinyl derivatives IIla,b are formed in 70% yield, while only 1.5-2% of the di-adduct IV are found in the reaction mixture.

Table 1 shows that addition is not stereospecific: in all experiments the vinyl derivatives are formed as a mixture of cis- (IIIa) and trans- (IIIb) isomers with the latter always in a greater or lesser excess. Stereoselectivity is increased at lower temperature and in the absence of initiator. The yields of products reach 90% at 30-35°C.

It should be noted that addition to the C≡CH bond occurs less actively in the presence of inhibitor of radical reactions – hydroquinone – so indicating that the reaction is homolytic.

Reaction of 1-heptanethiol with 5-ethynyl-2-methylpyridine (II) under the same conditions (30-35°C) occurs similarly to give 87% yield of 1:3 mixture of two unsaturated mono-addition products – cis,trans isomers of 5-(2-heptylthioethenyl)-2-methylpyridine (Va,b).

TABLE 1. Addition of Alkanethiols la,b to 5-Ethynyl-2-methylpyridine (II)

<table>
<thead>
<tr>
<th>Alkanethiol</th>
<th>Initiator/inhibitor (In)</th>
<th>Mole ratio</th>
<th>Temperature, °C</th>
<th>Duration, h</th>
<th>Yield, mol %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1:II:In</td>
<td></td>
<td></td>
<td>mono-adduct</td>
</tr>
<tr>
<td>1-Butanethiol</td>
<td>Di-tert-butyl peroxide</td>
<td>10:1:0.1</td>
<td>140</td>
<td>4</td>
<td>18 (1/2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10:1:--</td>
<td>140</td>
<td>4</td>
<td>20 (1/1.8)</td>
</tr>
<tr>
<td></td>
<td>Benzoyl peroxide</td>
<td>1.5:1:0.15</td>
<td>100-110</td>
<td>5</td>
<td>76 (1/1.5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.5:1:--</td>
<td>100-110</td>
<td>5</td>
<td>72 (1/3)</td>
</tr>
<tr>
<td></td>
<td>Hydroquinone</td>
<td>1.5:1:0.3</td>
<td>30-35</td>
<td>50</td>
<td>30 (1/1.2)</td>
</tr>
<tr>
<td>1-Heptanethiol</td>
<td></td>
<td>1.5:1:--</td>
<td>30-35</td>
<td>50</td>
<td>84 (1/3)</td>
</tr>
</tbody>
</table>

The products of thiyl radical recombination, the disulfides Vla,b, have been observed in the reaction mixture in small quantities alongside the main products.

\[
\begin{align*}
2 \text{RS}^- & \rightarrow R-S-S-R \\
\text{Vla,b} & \quad \text{a R = C}_7\text{H}_{15}, \text{b C}_7\text{H}_{15}
\end{align*}
\]

The structures of the compounds synthesized have been confirmed by IR, mass, and \(^1\)H NMR spectroscopy.

So, study of the homolytic addition of 1-alkanethiols la,b to pyridylacetylene II has clarified the conditions for the addition of either one or two molecules of thiol to the \(\text{C}==\text{C}\) bond. One of the factors which affects the stereospecificity of the reaction is temperature. Mono-addition of thiols to the \(\text{C}==\text{C}\) bond of pyridylacetylene at 30-35°C gives high yield of the unsaturated 1:1 adducts (80-90%) with preferential formation of the trans-isomer. In the absence of initiator (di-tert-butyl peroxide, benzoyl peroxide) the high yields of these products are evidently due to the presence of trace amounts of peroxy compounds which are readily formed in the presence of atmospheric oxygen [2].

**EXPERIMENTAL**

IR spectra of KBr disks were recorded on a UR-20 instrument. Mass spectra were recorded on MX-1310 mass spectrometer. \(^1\)H NMR spectra of CDCl\(_3\) solutions were obtained with a Tesla-567A (100 MHz) instrument. GLC analysis of reaction mixtures was carried out with a Biokhrom-1 chromatograph using a glass column (200 × 0.3 cm) filled with 5% of SKTFT-50 on Inerton AW carrier (0.100-0.125 mm).

5-Ethynyl-2-methylpyridine was synthesized by a known method from 2-methyl-5-vinylpyridine [3]. Di-tert-butyl peroxide [4] and dibenzoyl peroxide [5] were prepared by known methods.

**Addition of 1-Alkanethiols la,b to 5-Ethynyl-2-methylpyridine (II). (General Method).** Glass ampoule (30 or 15 ml) was 1/2 to 1/3 filled with pyridylacetylene II (20 mmol) together with the calculated amount of thiol I and the initiator. The ampoule was sealed and maintained at the required temperature for the required time (Table 1). After cooling, the excess of thiol was removed and the residue was analyzed by GLC and TLC on Silufol UV-254 plates (1:2 acetone–hexane) and then distilled in vacuum. The fractions containing a mixture of the cis and trans isomers of III (165-169°C/6 mm Hg) or V (187-190°C/2 mm Hg) were separated on a silica gel column.