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Sulfoxide induced sigmatropic rearrangement (SISR) of methyl 1-methylsulfanylvinyll sulfoxides

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Treatment of methyl 1-methylsulfanylvinyll sulfoxides with sodium thiophenolate in MeOH gives 1-methylsulfonylalk-1-en-3-ols.

The sigmatropic rearrangement of allylic sulfoxides in the presence of a thiophilic reagent leads to allylic alcohols. A special sequence which includes this reaction is the rearrangement of α-aryl sulfinylacyclates to 4-hydroxyalk-2-enoate esters. In this sequence a thiophilic base first gives an in situ isomerization of the vinyl sulfoxide moiety into an allylic sulfoxide, which then undergoes a 2,3-sigmatropic rearrangement and a subsequent thiophilic cleavage of the thus-formed intermediate sultenic esters by the same base. A practical variant of this synthesis of γ-hydroxyalkenoic esters is the so-called SPAC (sulfoxide piperidine and carbonyl) reaction, in which the sultenic acyclates are prepared by a Knoevenagel-type condensation of an appropriate aldehyde and arylsulfinyl acetates, and subsequently rearranged under the same conditions in a one-pot operation.

Here we report on a new related sulfoxide induced sigmatropic rearrangement (SISR) of methyl 1-methylsulfanylvinyll sulfoxides. The required starting materials were conveniently prepared from the corresponding dithiocarboxylic esters by deprotonation with LDA and subsequent S-alkylation of the intermediate vinylsulfenate anion. The ketene dithioacetals thus prepared were oxidized to the S-oxides of dithioesters by the same base.

Table 1 Synthesis of compounds 3

<table>
<thead>
<tr>
<th>Substituents</th>
<th>Product yields (%)</th>
<th>E : Z ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>R R' 1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a Et</td>
<td>95</td>
<td>95</td>
</tr>
<tr>
<td>b Pr</td>
<td>98</td>
<td>98</td>
</tr>
<tr>
<td>c Bn</td>
<td>85</td>
<td>83</td>
</tr>
<tr>
<td>d PhO(CH₂)₂</td>
<td>30</td>
<td>98</td>
</tr>
<tr>
<td>e -(CH₃)₂</td>
<td>75</td>
<td>98</td>
</tr>
</tbody>
</table>

Yields of pure isolated products. Determined by NMR spectroscopy.

Table 1 shows that all products a-e have been characterized by IR, mass and NMR spectroscopic data. The spectral characteristics revealed that all products 6 predominantly have the E configuration with E : Z ratio exceeding 90 : 10 (Scheme 2, Table 2).

For the SISR reaction, first the recommended conditions for the SPAC reactions were tried for substrate 3a. Prolonged treatment of 3a with a large excess of piperidine in MeCN at room temperature did not give any reaction. Reaction at 85 °C for five days, adding 10 equiv. of piperidine every day, gave a 70% yield of 1-methylsulfonylpent-1-en-3-ol 6a which had almost exclusively the E configuration (E : Z ratio greater than 95 : 5). More convenient conditions involved treatment with 5 equiv. of sodium thiophenolate in MeOH at room temperature for four days. In this manner 6a was obtained in 75% yield almost exclusively in the E form. The formation of 6a from 3a can be readily explained by invoking an initial base-induced prototropic shift to give allylic sulfoxide 4a, which then undergoes a 2,3-sigmatropic rearrangement to produce sulfenate ester 5a. Subsequent thiophilic reaction of 5a with thiophenolate then leads to product 6a. It is quite surprising that thiophenoxide serves as thiophilic reagent as well as base. These newly established conditions were also successful for the sequential prototropic shifts and sigmatropic rearrangement reactions of the substrates 3b-e. The corresponding 1-methylsulfonylalk-1-en-3-ols 6b-e were all obtained in yields ranging from 75-98%. The products 6a-e have been characterized by IR, mass and NMR spectroscopic data. The spectral characteristics revealed that all products 6 predominantly have the E configuration with E : Z ratio exceeding 90 : 10 (Scheme 2, Table 2).

Table 2.

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It is worth noting that the yield is also high for the formation of 6e, where the initial isomerization is accompanied by a considerable increase of torsional strain.

The SISR reaction of sulfoxides 3, of which no precedent is known in the literature, leads to ß-hydroxy vinyl sulfides, which can serve as a synthetic equivalent for ß-hydroxy aldehydes. The synthetic potential of this new SISR reaction is currently under investigation, including chirality transfer from sulfur to carbon when optically active sulfoxides are used as the substrates. Furthermore, the SISR reaction will be investigated for vinyl sulfoxides with other heteroatoms at the geminal position of the sulfoxide group.

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Footnote

† Selected data for E-6a: yellow oil; \( \nu_{\text{max}}(\text{CCl}_3)/\text{cm}^{-1} \) 3620 (OH); \(^1\)H NMR (200 MHz, CDCl\(_3\)): \( \delta \) 0.88 (3 H, t, \( J \) 7.7 Hz), 1.20–1.75 (5 H, m), 4.10 (1 H, br s), 2.25 (3 H, s); \( J \) 6.5 Hz, 5.33 and 5.40 (1 H, dd, \( J \) 14.5 and 7.3 Hz), 6.25 (1 H, d, \( J \) 14.5 Hz); \(^13\)C NMR (50.3 MHz, CDCl\(_3\)): \( \delta \) 13.78, 14.31, 18.51, 39.38, 72.64, 126.25, 128.00; m/z 146 (M\(^+\)), 129 (M\(^+\)-H\(_2\)O).

For E-6b, yellow oil; \( \nu_{\text{max}}(\text{CCl}_3)/\text{cm}^{-1} \) 3610 (OH); \(^1\)H NMR (200 MHz, CDCl\(_3\)): \( \delta \) 6.20 (1 H, br s), 2.26 (3 H, s), 2.80 and 2.90 (2 H, ABq, \( J \) 13.6, 7.8 and 5.8 Hz), 4.40 (1 H, br q, \( J \) 4.4 Hz), 5.45 and 5.52 (1 H, dd, \( J \) 15.6 and 7.0 Hz), 6.33 (1 H, d, \( J \) 15.7 Hz), 7.40–7.60 (5 H, m); \(^13\)C NMR (50.3 MHz, CDCl\(_3\)): \( \delta \) 14.30, 44.02, 73.35, 126.32, 126.64, 128.25, 129.39, 137.40; m/z 194 (M\(^+\)), 176 (M\(^+\)-H\(_2\)O).

For E-6c, yellow oil; \( \nu_{\text{max}}(\text{CCl}_3)/\text{cm}^{-1} \) 3620 (OH); \(^1\)H NMR (200 MHz, CDCl\(_3\)): \( \delta \) 1.59 (2 H, q, \( J \) 6.0 Hz), 2.15 (1 H, br s), 2.22 (3 H, s), 5.95–4.20 (2 H, m), 4.35–4.50 (1 H, m), 5.42 and 5.47 (1 H, dd, \( J \) 15.7 and 6.7 Hz), 6.35 (1 H, d, \( J \) 15.7 Hz), 6.85–6.95 (3 H, m), 7.20–7.35 (2 H, m); \(^13\)C NMR (50.3 MHz, CDCl\(_3\)): \( \delta \) 13.99, 36.33, 64.24, 69.62, 114.12, 120.37, 126.37, 126.82, 129.05, 158.31; m/z 224 (M\(^+\)).

For E-6d: yellow oil; \( \nu_{\text{max}}(\text{CCl}_3)/\text{cm}^{-1} \) 3615 (OH); \(^1\)H NMR (200 MHz, CDCl\(_3\)): \( \delta \) 1.30–1.50 (2 H, m), 1.50–1.70 (2 H, m), 1.85–1.95 (1 H, br s), 2.05 (3 H, s), 3.70–3.95 (2 H, m), 4.10–4.20 (1 H, m), 5.70–5.80 (1 H, m); \(^13\)C NMR (50.3 MHz, CDCl\(_3\)): \( \delta \) 16.27, 21.25, 28.06, 35.14, 74.45, 119.78, 142.73; m/z 144 (M\(^+\)).

References


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Table 2 Synthesis of 6 using thiophenoxide as thiophile

<table>
<thead>
<tr>
<th>Substituents</th>
<th>Yield of 6 (%)</th>
<th>E:Z ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>R'</td>
<td></td>
</tr>
<tr>
<td>a</td>
<td>Et</td>
<td>H</td>
</tr>
<tr>
<td>b</td>
<td>Pr</td>
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<td>Bn</td>
<td>H</td>
</tr>
<tr>
<td>d</td>
<td>PhO(CH(_2))(_2)</td>
<td>H</td>
</tr>
<tr>
<td>e</td>
<td>-(CH(_2))(_2)-</td>
<td>H</td>
</tr>
</tbody>
</table>

* Yields of pure isolated products. † Determined by NMR spectroscopy.