CHEMISTRY OF POLYENIC AND POLYYNIC COMPOUNDS

COMMUNICATION 14. DIACETYLENIC ALDEHYDE ACETALS AND THEIR USE IN THE SYNTHESIS OF 2-ALKEN-4,6-DIYNOIC ACIDS

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As shown earlier [1], the reaction of the organomagnesium derivative of 2-methyl-3,5-hexadiyn-2-ol (I), protected on the hydroxy group, with orthoformic ester provides a convenient method for the synthesis of 6-hydroxy-6-methyl-2,4-heptadienal diethyl acetal (II). With the object of extending this method for the synthesis of diacetylenic acetals not containing hydroxy groups, we studied the reactions of 1,3-alkadiynes with orthoformic ester and the thermal cleavage of the previously described acetal (II). It was found that the pyrolysis of this acetal in presence of a little potassium hydroxide goes with the elimination of acetone [2] and leads in satisfactory yield to 2,4-penta-diynal acetal (III), which is the first member of this type of diacetylenic acetals. For the synthesis of its homologs we successfully applied the reaction of the MgBr compounds of the 1,3-alkadiynes (IV) with orthoformic ester, and the acetals (V) obtained in this way are listed in the table.

\[
\begin{align*}
\text{CH}_3 \quad & | \\
\text{C} \equiv 
\text{C} \equiv 
\text{C} \equiv 
\text{C} \longrightarrow 
\text{CH} \quad & | \\
\text{CH}_3 \quad & | \\
\text{OR} & \\
(I) & \\
\end{align*}
\]

\[
\begin{align*}
\text{CH}_3 \quad & | \\
\text{C} \equiv 
\text{C} \equiv 
\text{C} \equiv 
\text{C} \longrightarrow 
\text{CH} \quad & | \\
\text{CH}_3 \quad & | \\
\text{OH} & \\
\text{KOH} & \\
(II) & \\
\end{align*}
\]

\[
\begin{align*}
\text{CH} \equiv 
\text{C} \equiv 
\text{C} \equiv 
\text{C} \equiv 
\text{CH} \quad & | \\
\text{CH}_3 \quad & | \\
(III) & \\
\end{align*}
\]

\[
\begin{align*}
\text{R} \quad & | \\
\text{C} \equiv 
\text{C} \equiv 
\text{C} \equiv 
\text{C} \equiv 
\text{CH} \quad & | \\
\text{CH}_3 \quad & | \\
\text{CH} \equiv 
\text{C} \equiv 
\text{C} \equiv 
\text{CH} \quad & | \\
\text{CH}_3 \quad & | \\
(IV) & \\
(V) & \\
\end{align*}
\]

It was of interest to determine the possibility of hydrolyzing the acetal grouping in these compounds, which was important for the further lengthening of the carbon chain. It was found that the optimum conditions for such hydrolysis was a short boil of the diacetylenic acetal with dilute hydrochloric acid in dioxane. However, the aldehydes then formed are very unstable compounds, which makes their isolation difficult. Only 2,4-hexadiynal (VI) were we able to isolate in a fairly pure state: we prepared it both by the hydrolysis of the acetal (Va) and by the reaction of the organomagnesium derivative of 1,3-pentadiyne with dimethylformamide by the procedure described previously [3, 4].

\[
\begin{align*}
\text{CH}_3 \quad & | \\
\text{(C} \equiv 
\text{C})_2 \quad & | \\
\text{CH} \equiv 
\text{CH} \quad & | \\
\text{(CH}_3)_2 \text{NCHO} & \\
(Va) & \\
\end{align*}
\]

\[
\begin{align*}
\text{CH}_3 \quad & | \\
\text{(C} \equiv 
\text{C})_2 \quad & | \\
\text{CHO} \quad & | \\
\text{(VI)} & \\
\end{align*}
\]

Despite the difficulty of working with higher diacetylenic aldehydes, they were used with success in further syntheses without isolation in the pure state. Thus, by the condensation of an ethereal solution of the aldehyde (VII)
Diacetylenic Aldehyde Acetals

<table>
<thead>
<tr>
<th>Formula</th>
<th>Yield, %</th>
<th>B. p., °C (p, mm)</th>
<th>nD</th>
<th>Found, %</th>
<th>Calculated, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH≡C≡C≡C=CH(OEt)2</td>
<td>52,5</td>
<td>85(15)</td>
<td>1.4708</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>CH3C≡C≡C≡C=CH(OEt)2</td>
<td>54,6</td>
<td>63–64(0,6)</td>
<td>1.4838</td>
<td>72,48</td>
<td>72,26</td>
</tr>
<tr>
<td>C2H5C≡C≡C≡C=CH(OEt)2</td>
<td>54,0</td>
<td>61(0,55)</td>
<td>1.4792</td>
<td>73,26</td>
<td>73,30</td>
</tr>
<tr>
<td>C2H5C≡C≡C≡C=CH(OEt)2</td>
<td>54,5</td>
<td>85–87(0,7)</td>
<td>1.4798</td>
<td>74,20</td>
<td>74,19</td>
</tr>
<tr>
<td>C2H5C≡C≡C≡C=CH(OEt)2</td>
<td>55,7</td>
<td>98–99(0,7)</td>
<td>1.4798</td>
<td>74,95</td>
<td>74,96</td>
</tr>
</tbody>
</table>

Formed in the acid hydrolysis of the acetal (Vb) with methyl (triphenylphosphoranylidene)acetate we obtained an 80% yield of methyl trans-2-decen-4,6-diynoate (VIII) ("lachnophyll ester"), which is an ester of the simplest member of the interesting class of natural 2-alken-4,6-diynoic acids [5]. The methods reported in the literature for the synthesis of such compounds are based on the mixed oxidative coupling of acetylenic derivatives and usually give the required products in low yield only [6-8].

\[
\text{n-C}_3\text{H}_7 - (\text{C} \equiv \text{C})_2 - \text{CH(OEt)}_2 \rightarrow \text{n-C}_3\text{H}_7 - (\text{C} \equiv \text{C})_2 - \text{CHO} \\
\text{Vb} \\
\downarrow \\
\text{(VII)}
\]

\[
\text{n-C}_3\text{H}_7 - (\text{C} \equiv \text{C})_2 - \text{CH} = \text{CH} - \text{COOCH}_3
\]

\[
\text{n-C}_4\text{H}_9 - (\text{C} \equiv \text{C})_2 - \text{CH(OEt)}_2 \rightarrow \text{n-C}_4\text{H}_9 - (\text{C} \equiv \text{C})_2 - \text{CH} = \text{CH} - \text{COOR} \\
\text{IX} \quad R = \text{C}_3\text{H}_5; \quad \text{(X)} \quad R = \text{H}
\]

From the acetal (Vc) by the above-described method we synthesized ethyl trans-2-undecen-4,6-diynoate (IX), by the hydrolysis of which we obtained the corresponding acid (X) in good yield.

**EXPERIMENTAL**

2,4-Pentadiynal Acetal (III). A mixture of 4.5 g of the acetal (II) and 0.05 g of KOH was heated at a bath temperature of 140° at a residual pressure of ~10–15 mm with collection of the reaction products in a receiver cooled with solid carbon dioxide. Fractionation of the pyrolysis product gave 1.6 g (52.5%) of the acetal (III), b. p. 82° (15 mm); nD 1.4708. Found: C 71.30; 71.85; C9H12O2. Calculated: C 71.02, H 8.59%.

General Method for the Synthesis of Diacetylenic Acetals (V). A solution of 0.1 mole of the 1,3-alkadiyne (IV) in 10 ml of dry ether was added in the course of 15 min at 6–10° to a Grignard reagent prepared from 2.64 g of magnesium and 12 g of ethyl bromide in 50 ml of dry ether, after which the reaction mixture was stirred for 2 h at room temperature. At this temperature an ethereal solution of 0.1 mole of orthoformic ester was added slowly, and the mixture was stirred for 3 h at 15-20° and for 2-3 h at the boiling point of ether. The reaction complex was decomposed by the addition of saturated ammonium chloride solution. The reaction product was carefully extracted with ether, the extract was dried with anhydrous magnesium sulfate, ether was driven off, and the residue was vacuum-distilled. The constants of the diacetylenic acetals obtained are given in the table.

2,4-Hexadiynal (VI). 5 ml of water and 1 ml of 1 N HCl were added to a solution of 5.5 g of the acetal (Va) in 25 ml of dioxane, and the mixture was heated at the boil for 15 min. The reaction mixture was diluted with water and extracted with ether, and the extract was dried over anhydrous magnesium sulfate. Ether was driven off in a vacuum, and in a stream of nitrogen the residue was distilled over at as low a temperature as possible. We obtained 1.05 g (34.5%) of the aldehyde (VI), b. p. 25–26° at 0.7 mm; nD 1.5496; λmax (in ethanol) 242; 256; 271; 287 mμ. Found: C 77.99; 77.70; H 4.45; 4.62%; C6H4O. Calculated: C 78.25; H 4.38%. The 2,4-dinitrophenylhydrazone of this aldehyde melted at 143–144° (decomp.). Found: C 52.90; 52.99; H 3.00; 3.02; N 20.20; 20.18%. C12H8N4O4. Calculated: C 52.94; H 2.96; N 20.58%.