SYNTHESIS OF ESTERS OF STEREOISOMERIC
4,5-DIMETHYLHEPTA-2,4-DIEN-6-YNOIC ACIDS

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Previously it was shown [1] that the primary bromide (I), formed in the allylic isomerization of 2,3-dimethyl-1-penten-4-yn-3-ol, is a mixture of the geometric isomers, which was shown to contain approximately 65-70% of the cis-isomer, based on the results of the intramolecular cyclization of the product obtained from it by condensation with sodiomalonate ester.

It seemed of interest to obtain the corresponding stereoisomeric aldehydes (II), which could then be used for a further lengthening of the chain at either the aldehyde or the acetylene end. Reaction of the mixed bromides (I) with the K salt of 2-nitropropane [2] gave the necessary 2,3-dimethyl-2-penten-4-ynal (II) in up to 35% yield; its structure was confirmed by the data of the infrared and ultraviolet spectra. It is possible to assume that this product, the same as the starting bromide, is a mixture of the cis- and trans-isomers, but we were unable to effect their separation by gas-liquid chromatography (GLC). A fairly reliable solution to this problem was obtained on the basis of analyzing the products obtained from the condensation of aldehyde (II) with the diethyl ester of carbethoxymethylene phosphonic acid

\[ \text{HC} \equiv \text{CC} (\text{CH}_3) \text{C} \equiv \text{CH} \rightarrow \text{HC} \equiv \text{C} \equiv \text{CH}_2 \text{Br} \xrightarrow{\text{AcOK}} \text{HC} \equiv \text{CC} \equiv \text{C} \equiv \text{CH}_2 \text{OAc} \]

\[ \text{HC} \equiv \text{CC} \equiv \text{C} \text{CHO} \xrightarrow{\text{MnO}_2} \text{HC} \equiv \text{CC} \equiv \text{C} \equiv \text{CH}_2 \text{OH} \]

\[ \text{HC} \equiv \text{CC} \equiv \text{C} \equiv \text{C} \equiv \text{CH}_2 \equiv \text{OEt} \]

\[ \text{HC} \equiv \text{C} \equiv \text{C} \equiv \text{CH}_3 \equiv \text{CH}_3 \equiv \text{H} \equiv \text{C} \equiv \text{C} \equiv \text{H} \equiv \text{C} \equiv \text{C} \equiv \text{CO}_2 \text{R} \equiv \text{C} \equiv \text{C} \equiv \text{H} \equiv \text{C} \equiv \text{C} \equiv \text{CO}_2 \text{R} \]

It proved that the liquid reaction product obtained here in up to 45% yield is a mixture, analyzing 65% of the cis- and 35% of the trans-isomers of the ethyl esters of 4,5-dimethylhepta-2,4-dien-6-ynoic acid, (III) and (IV) which could be separated by chromatographing on alumina oxide. The isolated stereoisomeric esters are comparatively stable crystalline products, the infrared spectra of which are identical in the region of the nonplanar deformation vibrations of the C-H bonds (700-1100 cm\(^{-1}\)); consequently, they have the same geometry at the unsubstituted double bond and, in harmony with the steric rules of the Wittig-Horner reaction [3], have the trans-configuration at these bonds.

To prove the isomerism at the 4,5 double bond of the obtained esters (III) and (IV), we studied their ultraviolet spectra. It is known [4-6] that trans-isomers, having approximately the same absorption maximum as the cis-isomer, possess a much higher extinction coefficient (by 3-8 thousand). It proved that the isomeric ester (III),
formed in predominant amount, has a lower extinction coefficient at 295 m\(\mu\) and, consequently, has the cis-configuration at the 4,5 double bond. These data indicate that aldehyde (II), obtained by the direct oxidation of bromide (I), is a mixture of the geometric isomers with a sharp predominance of the cis-product.

A different ratio of the isomeric aldehyde is formed when 2,3-dimethyl-2-penten-4-yn-1-ol (V), obtained from bromide (I) by the saponification of the corresponding acetate, is oxidized with manganese dioxide. The reaction of this aldehyde with the diethyl ester of carboxyoxymethylene (or carboxymethoxymethylene) phosphonic acid gives a mixture of the above described isomeric esters of 3,4-dimethylhepta-2,4-dien-6-ynoic acid, with a noticeable predominance (according to the GLC data, above 70%) of the 4,5-trans-product (IV, \(R = \text{C}_6\text{H}_5\) or \(\text{CH}_3\), respectively), which are easily isolated in the pure state by chromatographing on aluminum oxide. An increase in the amount of the trans-isomer in the aldehyde, formed in the oxidation of 2,3-dimethyl-2-penten-4-yn-1-ol (V), is apparently associated with a loss of the less stable cis-form in the process of obtaining the aldehyde by this route.

**EXPERIMENTAL**

2,3-Dimethyl-2-penten-4-yn-1-al (II). To a solution of the crude bromide (I) in 70 ml of methanol, obtained from 55 g of 2,3-dimethyl-1-penten-4-yn-3-ol by reaction with phosphorus tribromide [7], with vigorous stirring, at 2-5\(^\circ\), was gradually added a cooled solution of the K salt of nitropropane (from 32 g of KOH, 24 ml of water, 170 ml of methanol and 45 ml of 2-nitropropane) [2]. The mixture was then held for 2 h and stirred until room temperature was reached.

The reaction mixture was poured over ice and then repeatedly extracted with hexane; the extract was washed twice each with cooled solutions of 0.5 N KOH, 0.5 N sulfuric acid and bicarbonate, and then it was dried over magnesium sulfate in the presence of hydroquinone. After vacuum-distillation we obtained 20 g of product with b.p. 25-30\(^\circ\) (2 mm) (bath temperature not exceeding 50\(^\circ\)) and \(\delta^D_{25} 1.5080-1.5124\), being a pale yellow, strongly lachrymatory liquid, which was extremely unstable when stored and congealed easily when cooled to -10\(^\circ\). This product, based on the GLC data (Silicone on sodium chloride, temperature 85\(^\circ\)), contains at least 90\% of the desired aldehyde (II), and in the ultraviolet spectrum has an absorption maximum at 269 m\(\mu\), \(\epsilon\) 10,000 (in alcohol). The 2,4-dinitrophenylhydrazone was obtained as bright red crystals with m.p. 145-147\(^\circ\) (with decomp. from a mixture of ethyl acetate and petroleum ether); \(\lambda_{\text{max}}^\text{max}\) (in alcohol) 385 m\(\mu\). Found: C 54.24, 54.49; H 4.32, 4.51; N 19.10, 18.99\%. \(\text{C}_{12}\text{H}_{12}\text{N}_{4}\text{D}_{4}\). Calculated: C 54.16; H 4.20; N 19.44\%.

Ethyl esters of isomers of 4,5-dimethylhepta-2,4-dien-6-ynoic acid (III) and (IV). To a solution of 34.0 g of the diethyl ester of carboxyoxymethylene phosphonic acid [8] in 240 ml of dimethylformamide was added 100 ml of sodium ethylate (from 3.7 g of sodium), the mixture was stirred for 1 h, and then, at 20-25\(^\circ\), a solution of 18.0 g of the above obtained mixture of the isomers of aldehyde (II) in 40 ml of dimethylformamide was added gradually. The mixture was heated at 50\(^\circ\) for 1 h, poured over ice, and the reaction product was extracted well with ether and then dried over magnesium sulfate.

After vacuum-distillation we obtained 12.0 g of a mixture of the stereoisomeric esters (III) and (IV), with b.p. 45-55\(^\circ\) (0.06 mm), which, based on the GLC data (Silicone on sodium chloride, 125\(^\circ\)), contains these isomers in a 2 : 1 ratio. When 3.0 g of this fraction was chromatographed on 500 g of aluminum oxide of II activity, using a mixture of hexane and benzene for elution, we isolated 0.7 g of the ethyl ester of acid (IV), with m.p. 43-43.5\(^\circ\) (from hexane); \(\lambda_{\text{max}}^\text{max}\) (in alcohol) 297.5 m\(\mu\), \(\epsilon\) 29500; the infrared spectrum (in CHCl\(_3\)) exhibits characteristic absorption bands at 2125, 1718, and 1624 cm\(^{-1}\). Found: C 74.26, 74.40; H 8.06, 8.21\%. \(\text{C}_{11}\text{H}_{16}\text{O}_{2}\). Calculated: C 74.13; H 7.92\%.

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2,3-Dimethyl-2-penten-4-yn-1-ol (V). A mixture of 20 g of 2,3-dimethyl-2-penten-4-yn-1-ol acetate [7] and 400 ml of 1 N KOH solution in methanol was heated at 55-60\(^\circ\) for 1 h, cooled, evaporated in vacuo, diluted with water, repeatedly extracted with ether, and dried over potassium carbonate. After distillation we obtained 6.2 g of alcohol (V), unstable when stored, with b.p. 34-39\(^\circ\) (1.5 mm); \(\delta^D_{20} 1.4910-1.4928\); \(\lambda_{\text{max}}^\text{max}\) (in alcohol) 229 m\(\mu\), \(\epsilon\) 13400. Found: C 76.02, 75.84; H 9.01, 8.89\%. \(\text{C}_{7}\text{H}_{10}\). Calculated: C 76.32; H 9.15\%.

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