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ENOLATE ION CONFORMATIONS. STEREOCHEMISTRY OF O-ALKYLATION OF ETHYL ACETOACETATE ALKALI ENOLATES

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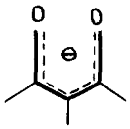
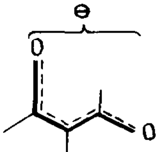
The planar enolate ions of acyclic β-dicarbonyl compounds can exist in any one or all of three conformations known as the "U" - shaped, the sickle- ("s") shaped and the "W" - shaped[1]. In dipolar aprotic solvents "W" shaped conformations are more stable, while in protic solvents enolate ions adopt the alternative "U" - shaped conformation that could be ascribed to hydrogen - bond stabilization by protic solvent of the respective anionic ground state. The relative reactivity of these conformations can be estimated by studying of stereochemistry of the reaction at the oxygen center of the ambident anions[2]. If the free enolate ion is the reactive particle and if the O-isomer obtained posseses trans - configuration, this means that the enolate ion reacts in the "W" shaped form exclusively. If the only cis - isomer is formed, this shows that "U"-shaped conformation is more reactive because the energy barrier between "U" - and "W"- forms must be higher than that between "s" - and "W"-shaped forms.


„U"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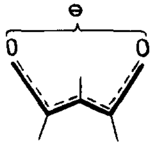
„W"

In this paper we wish to report our results on study of stereochemistry of O-alkylation of ethyl acetoacetate alkali salts by ethyl tosylate in hexamethylphosphoric triamide (HMPT). At 0,01 - 0,1M range of the enolate concentration, at which the reactive particle was shown, for all alkali enolates[3], to be free enolate ion exclusively, the trans-isomer only was found as the O-reaction product. This means that the enolate ion reacts in W-shaped conformation. The occurence of cis-isomer should be expected at the transfer from K- to Li - enolate or with an increasing of enolate concentration. The alkylation of Li-enolate (Co=1M) by ethyl tosylate in HMPT at 80°C leads to reaction mixture which contains ethyl β-ethoxy-cis-crotonate[x] (39%), ethyl β-ethoxy-trans-crotonate (29%), ethyl α-ethylacetoacetate (28%), ethyl α,α-diethylacetoacetate (2%) and cis-and trans -ethyl α-ethyl β-etoxy- crotonate (2%; ~ 1:1; O,C - isomers). The reaction mixtures were analyzed by GLC (17% apiezon L on chromosorb W, column temperature was 110° and the nitrogen flow rate was $100 \frac{ml}{min}$) and N M R techniques. N M R spectra of the alkylation products shows the acetyl proton signals at δ 2,13 ppm and the allyl proton signals at δ 1,98 ppm for cis-and 2,24 ppm for trans - isomers and vinyl proton signals (4,74 for cis-and 4,86 ppm for trans - O - isomers). After the reaction mixtures were stirred with 3%HCl the peaks for both cis-and trans-O-isomers disappeared in the NMR spectrum and GL-chromatogram. The composition of the alkylation products for different alkali salts of ethyl acetoacetate by ethyl tosylate in HMPT is shown in Table 1.

Table 1

The ratio (in per cents) of O - and C - isomers in the alkylation of alkali enolate of ethyl acetoacetate by ethyl tosylate in HMPT, $C_o = 1 \frac{M}{l}$; t = 25°

Metal	Total yield	O - isomer		C-	C,C-	C,O-
		trans -	cis -			
Cs	93	83	<1	11	3	3
K	90	81	<1	14	3	2
Na	82	82	<1	15	2	1
Li	79	42	29	28	1	<1

This data shows that the yields of O-isomer are practically the same for Na-, K - and Cs-enolates. The C/O - ratio for these enolates (0,21-0,22) is rather close to the ratio that was observed for the free enolate - ion (0,13[3]), and yields of cis-isomer were less than 1%. We believe that in 1M concentration

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[x] Cis- and trans - isomers denote cis - and trans - position of the two polar groups OR and COOR at the double bond.

in HMPT these enolates react essentially as the solvent - separated ion pair in "W" - conformation. The intimate ion pair should be more stable in its chelate "U"- conformation and therefore the cis-isomer should be formed. For Li-enolate considerable increasing of the C/O-ratio and of the cis-isomer yield were observed (Table 1). This seems to be evidence for participation in the reaction of both the solvent - separated (W) and the intimate (U) ion pairs. In DMF as a solvent, the yield of the O-isomer increases in the order Li< Na<K<Cs and all alkali enolates give the cis-isomer when $C_o > 0{,}3$ M (Tables 2 and 3). The yield of cis - isomer increases at the transfer from Cs- to Li-enolate (Table 2), and $\frac{trans}{cis}$ - ratio decreases as the concentration of enolate becomes higher (Table 3).

Table 2

The ratio (in per cents) of O-and C-isomers in the alkylation of alkali salts of ethyl acetoacetate by ethyl tosylate in DMF, $t=25^{o}$, $C_{o}=0{,}3\ \frac{m}{l}$

Metal	O - isomer		C-	C,C-	O,C-	$\frac{C}{O}$	$\frac{trans}{cis}$
	trans -	cis -					
Cs	74	4	18	3	1	0,23	19
K	70	5	23	2	<1	0,31	14
Na	51	8	40	1	<1	0,68	6,4
Li	26	20	54	<1	<1	1,18	1,3

The C/O-ratio does not change at the enolate concentration below than 0,05 M and the same ratio was observed for ethylation 0,01 - 0,1 M solution of alkali salts of ethyl acetoacetate by ethyl tosylate in HMPT[3]. This means that in DMF, at the concentration region below 0,05 M the enolate ion is the reactive particle.

In both HMPT and DMF in this region of concentration the cis - isomer was found only in the trace amounts. Thus in dipolar aprotic solvents the enolate ion reacts in its "W" shaped conformation giving trans - O - isomer.

Contrary the alkylation of the bidentate chelate form of the enolate in "U" - shaped conformation must give cis - isomer. Indeed, alkylation of sodium eno-

Table 3

Influence of substrate concentration on the ratio (in per cents) of O-and C-isomers in the alkylation of potassium enolate of ethyl acetoacetate by ethyl tosylate in DMF

C_0(M/l)	O - isomer		C-	C,C-	O,C-	$\frac{C}{O}$	$\frac{trans}{cis}$
	trans -	cis -					
0,01	88	< 1	11	1	<1	0,13	>90
0,05	85	2	12	1	<1	0,14	~50
0,1	81	3	15	1	<1	0,18	~30
0,3	70	5	23	2	<1	0,31	14
3	45	5	47	3	<1	0,94	9
5	36	5	56	3	<1	1,37	7
7,5	26	4	60	10	<1	2,0	6

late of ethyl acetoacetate by triethyloxonium fluoroborate in ether leads to cis - O - isomer[4].

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