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ALUMINUM OXIDE CATALYZED ISOMERIZATION OF ACYLATED CYCLOALKENES

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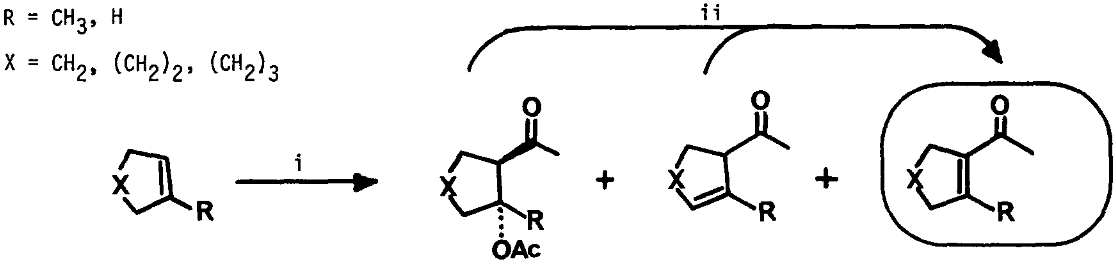
Abstract: A homologous series of cyclic olefins and their corresponding 1-methyl derivatives were acylated using acetic anhydride/zinc chloride system. The resulting mixtures were, after appropriate analysis, isomerized quantitatively to the conjugated enones by adsorption on neutral alumina. A detailed, general experimental procedure is given.

Acylated cycloalkenes constitute a versatile class of synthetic intermediates. They may be useful in the generation of quaternary centers[2] via organocuprate addition-alkylation sequence[3] or they can act the role of dienophiles in the Diels-Alder reaction.[4]

We required a homologous series of cyclic enones of the type 4 as starting materials in a synthesis of exocyclic dienes and dienic esters. The literature offered a variety of methods for the acylation of cyclic olefins,[5] however, a number of reports indicated the procurement of equilibrium mixtures containing also the corresponding β,γ-unsaturated ketones.[6] The usual remedy, namely, the base catalyzed isomerization, is especially unsuccessful in those cases where the production of tetrasubstituted enone would force the peripheral substituents to planarity thereby creating a steric congestion.



R = CH_3, H
X = CH_2, $(CH_2)_2$, $(CH_2)_3$

1 2 3 4

Reagents: i. $AC_2O/ZnI_2/ZnCl_2/0^oC$; ii. Al_2O_3/R.T.

Literature procedures indicated varying amounts of ketones 2, 3 and 4 in the crude acylation mixtures, their composition depending chiefly on the quality of Lewis acid used,[7] and in some cases reported the production of conjugated enones after several base catalyzed isomerizations.[5,6]

We have found that 1-acetyl-2-methylcyclopentene could be isolated from the acylation mixtures in poor yields only after several treatments with sodium methoxide, always accompanied by the deconjugated isomer. Following a cue from previously attempted surface catalyzed reactions of various types,[8,9] we found that adsorption of the crude product (free of any HOAC or Ac_2O, however!) on neutral alumina for a period of 12 hours produced enones 4 quantitatively with respect to the original mixtures. We found this extremely useful especially when we noted that the tetrasubstituted enones behaved in an identical manner.

The results of our study are summarized in Table 1.[10] In each instance the overall distilled yields of 4 superceeded yields obtained from isomerizations by base. The detailed experimental procedure below is given for the case of 1-methylcyclopentene, the acylation of which proved the most difficult.

Acknowledgments

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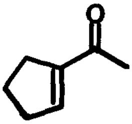
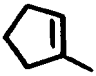
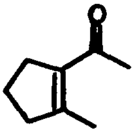
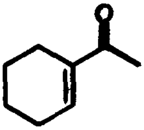
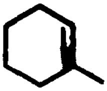
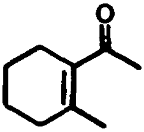
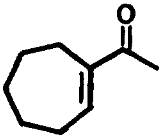
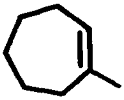
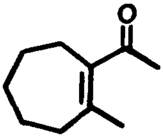
Experimental

1-Methylcyclopentene[11] (8.2g; 0.1m) was dissolved in 60 ml of acetic anhydride and the solution cooled to 0°C. A few crystals of anhydrous zinc iodide were added and the mixture stirred for 15 minutes. Zinc chloride (14g; 0.1m) was added at once and the reaction mixture kept stirring at 0°C for 2 hours. The mixture was decomposed with ice, extracted with ether, the organic layers washed with 10% NaOH until the aqueous layer remained alkaline, and the ether removed in vacuo. If freshly fused zinc chloride were used, the resulting

Table 1

Starting Olefin	Composition of Crude Mixtures[a]			Enone, Yield[b]		
1	2	3	4	B.P./mm	4	%
	40	30	30	29/0.3		74
	10	70	20	44/0.8		78
	40	30	30	47/0.3		79
	10	88	2	40-1/0.2		82
	52	22	26	68-9/1.5		77
	2	85	13	58/0.8		72

[a] estimated by gas chromatography (SE-30, I_1=70°, T_2=160°C

[b] distilled yield after isomerization

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oil could be distilled to give 10.4g (83%) of 3, b.p. 34-6°C/0.8mm, IR (neat) cm^{-1} 1705; ^1H-NMR ($CDCl_3$) δ 1.8 (m, 2H), 2.05 (s, 3H), 2.12 (s, 3H), 2.4-2.6 (m, 2H), 3.4 (M, 1H), 5.6 (br t, 1H).

If reagent grade $ZnCl_2$ were used, the mixture consisted of (1:7:2) proportions of 2, 3[10] and 4 (see Table 1). The crude oil was either dried in vacuo or quickly distilled to remove any acetic acid and adsorbed on a column bed of neutral aluminum oxide (Baker), [3 fold excess of alumina over the volume of crude oil]. 5 ml of dichloromethane were used to partially elute the material from the origin. After twelve hours, the column was rinsed with 150 ml of dichloromethane and the oil obtained after evaporation distilled to give 9.6g (78%) of 4, b.p. 44°C/0.8mm IR (neat) cm^{-1} 1675, 1640, 1610; ^1H-NMR ($CDCl_3$) δ 1.8 (m, 2H), 2.1 (br.s, 3H), 2.2 (s, 3H), 2.3-2.7 (m, 4H); ^{13}C-NMR ($CDCl_3$) δ 16.7 (q), 21.6 (t), 30.3 (q), 34.5 (t), 41.2 (t), 135.8 (s), 153.7 (s), 197.6 (s); mass spectrum (70 eV) 124 (M^+), 109, 81, 79, 58.

Spectral data for acetate 2: IR (neat) cm^{-1} 1730, 1700; ^1H-NMR ($CDCl_3$) δ 1.2 (s, 3H), 1.4-2.0 (M, 6H), 2.0 (s, 3H), 2.2 (s, 3H), 3.2 (br. t, 1H): ^{13}C-NMR ($CDCl_3$) δ 20.5 (q), 21.4 (q), 21.9 (t), 25.8 (t), 31.5 (q), 39.7 (t), 59.6 (d), 89.5 (s), 170.1 (s), 209.0 (s).

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6. a) J. K. Groves and N. Jones, Tetrahedron Lett. 1161 (1970); b) J. K. Groves and N. Jones, J. Chem. Soc. (C), 608 (1969).
7. The quality of $ZnCl_2$ affects the yields of enones at the expense of products derived from carbocations trapped by HOAc. See Ref. 5c above.
8. S. Danishefsky, J. Morris, G. Mullen and R. Gammill, J. Am. Chem. Soc. 102, 2838 (1980).
9. At least one report (Ref. 6b above) indicated that the base catalyzed isomerizations of 1-acetyl-2-methylcyclopentene always afforded small amounts of β,γ-isomer. The pure α,β-enone was then obtained by chromatography on alumina!
10. Compounds 2 and 3 were isolated and subjected to the alumina isomerization separately, each having been converted to 4.
11. Aldrich material (also prepared from distillation of methylcyclopentanol from oxalic acid/iodine).

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