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Lithium Iodide Promoted Rearrangement of Double Activated Alkenylcyclopropanes to Cyclopentenes or 1,3-Dienes

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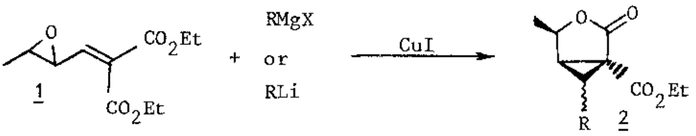
Key Words: *1-ethoxycarbonyl-4-methyl-6-alkenyl-3-oxabicyclo[3.1.0]hexan-2-ones: 1-ethoxycarbonyl-4-methyl-3-oxabicyclo-[3.3.0]oct-6-en-2-ones: 3-(1,3-alkadienyl)-4-methylbutanolides: lithium iodide: rearrangement.*

Abstract: Heating of bicyclic alkenylcyclopropanes 2a-g *in DMF with LiI results in good yields of cyclopentenes or conjugated dienes depending on a substrate structure.*

As we reported in our recent publication, reactions of diethyl(2,3-epoxybutylidene)malonate 1 with either Grignard reagents or organolithium compounds afford bicyclic lactones 2 in 65-85% yields.



R= alkyl, aryl,alkenyl, alkinyl.

Upon boiling in DMF with 3 equiv. LiI(0.5-2h) substrates 2a-g, each containing an alkenyl fragment, have been found to undergo rearrangement accompanied by opening of a cyclopropane ring (Table 1).

The rearrangement of cyclopropanes 2a-c having terminal double bonds gives cyclopentenes 3-5 .[2,3] Compounds 4,5 are found in a mixture with decarboethoxylation products 6,7.[4] Lower yields of cyclopentene 3 (39% or 23%) are obtained in the reaction of 2a when LiI is replaced by NaI or Bu_4NI, respectively. Much lower yields of 3 (10-15%) are observed if HMPA or DMSO are used as solvents.

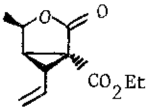
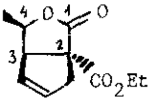
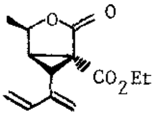
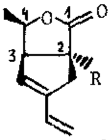
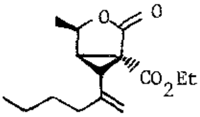
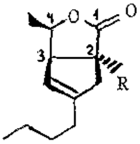
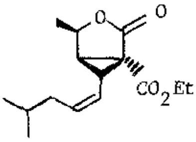
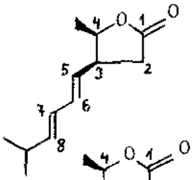
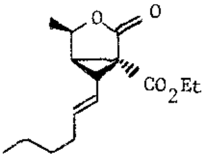
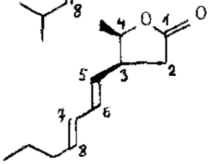
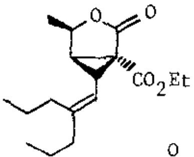
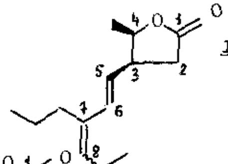
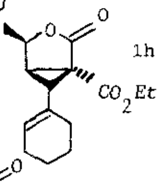
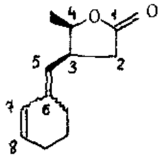
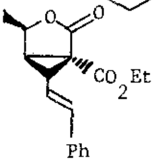
Conjugated dienes 8-11 are formed in the reaction with cyclopropanes 2d-g containing internal double bonds. According to the data of ^1H and ^{13}C NMR spectroscopy, disubstituted bonds C(5)=C(6) in 8-10 and C(7)=C(8) in 8, 9 exhibit trans-configuration ($J_{H(5)-H(6)}$ and $J_{H(7)-H(8)}$= 14-16 Hz). Compounds 10, 11 represent mixtures of E- and Z-isomers by their trisubstituted bonds C(7)=C(8) and C(5)=C(6), respectively.

Neither β-styryl derivative 2h nor 1,1-diethoxycarbonyl-2-vinylcyclopropane have been found rearranged under the conditions employed.

A typical experimental procedure for the synthesis of lactones 3-11 is as follows. A solution of cyclopropane 2a (420 mg, 2 mmole) and LiI (804 mg, 6 mmole) in DMF (10 ml) was stirred at 150°C. The reaction was monitored by TLC. After 40 min, the reaction mixture was cooled to 20°C and, following addition of water (20 ml), extracted with Et_2O (3 x 10 ml). The ether layer was dried by $MgSO_4$ and concentrated. Cyclopentene 3 (256 mg, 61%) was isolated as a colourless oil by column chromatography (silica gel L 40/100, hexane-Et_2O, 1:1). ^1H NMR ($CDCl_3$) δ 1.3(3H,t,J=7.2 Hz), 1.43(3H,d,J=6.5 Hz), 3.05(1H,ddd, J=17.4, 4.3, 2.3 Hz), 3.14(1H,ddd,J=17.4, 4.6, 2.5 Hz),3.73(1H,m), 4.25(2H, q,J=7.2 Hz), 4.94(1H,dq,J=6.5 Hz), 5.6(1H,m), 5.88(1H,m); ^{13}C NMR ($CDCl_3$)δ 14.01q, 16.78q, 40.41t, 56.86d, 61.75s, 62.21t, 78.46d, 125.26d, 132.84d, 169.00s, 175.85s; IR (film): 3075, 1770, 1735, 1620 cm^{-1}; m/e 210 (M^+).

A key stage in the rearrangement of the alkenylcyclopropanes 2a-g to cyclopentenes 3-5 or 1,3-dienes 8-11 (relative configurations of atoms C(3) and C(4) are completely retained in both cases[6]) most likely represents a reversible nucleophile opening of the cyclopropane ring by anion I^-, hence enolates A (1,5-addition) or B, C (1,7-addition) are formed.[8] Moreover, this process is facilitated via coordination of Li^+ to the carbonyl oxygen (the rate of electrophilic assistance decreases from Li^+ to Na^+ and then to Bu_4N^+,as well as if DMF is changed for DMSO or HMPA that show higher solvation towards cations [9]). The derivatives A, B give only a starting cyclopropane during the cyclization[10], whereas enolate C is capable of cyclizing to a cyclopentene[11]. With the use of substrates 2d-g containing 1,2-di- or trisubstituted double bonds, steric hindrances prevent cyclization of enolate C (R^2 and/or R^3= alkyl). However, 1,4- and/or 1,2-elimination of HI in enolates A, B can be realized due to the presence of related CH_2-groups, leading to a diene system.[12] It should be noted that rigid bicyclic structures of 2a-g are required for the reaction to be a success.[3]

TABLE 1. LiI-Promoted Rearrangements of Alkenylcyclopropanes in DMF

	Substrate	Reaction time	Rearrangement Product[a]		Yield,%[b]
2a		40min		3	61
2b		2h		4 (R=CO_2Et) 6 (R=H)	65[c]
2c		2h		5 (R=CO_2Et) 7 (R=H)	84[d]
2d		1.5h		8	62
2e		1.5h		9	57
2f		30min		10(E/Z=50:50)	71
2g		1h		11(E/Z=85:15)	75
2h		6h	No reaction, only cyclopropane 2h was isolated		

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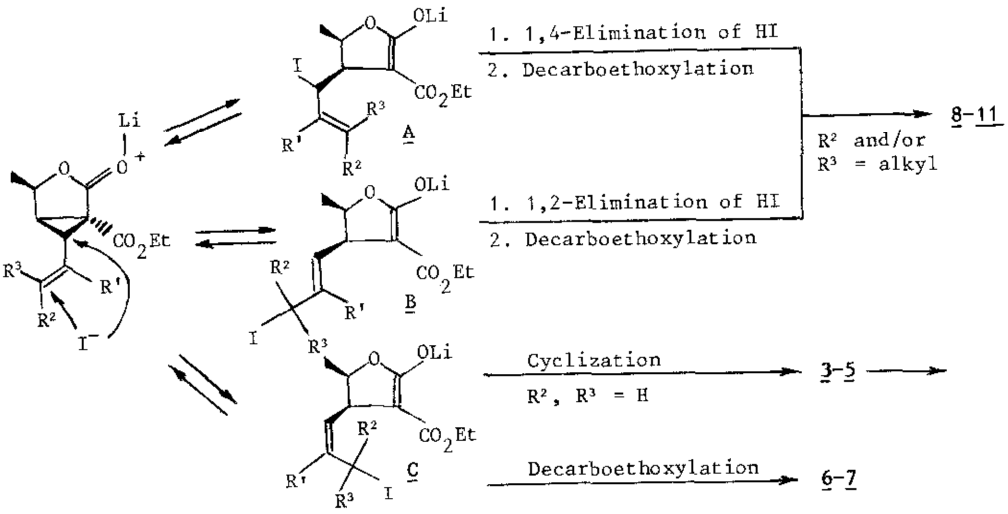
[a] All the compounds had satisfactory ^1H and ^{13}C NMR (300 MHz) and IR spectral assignments. Their mass-spectra and elemental analysis data were acceptable.

[b] Yields are given for isolated products.

[c] Total yield of 4 and 6, 4:6=74:36.

[d] Total yield of 5 and 7, 5:7=63:37.



Thus, the rearrangement described here is a convenient stereoselective method to synthesize lactones containing cyclopentene or 1,3-diene fragments. Potential applications of the reactions to the synthesis of natural products are now under study in our laboratory.

REFERENCES AND NOTES

1. Kasatkin, A.N.; Kulak, A.N.; Biktimirov, R.Kh.; Tolstikov, G.A. *Tetrahedron Lett.* **1990**, *33*, 4915.
2. On different rearrangements of alkenylcyclopropanes to cyclopentenes or 1,3-dienes (either thermal or catalyzed by Lewis acids or transition metal complexes),see review: Goldschmidt, Z.; Crammer, B. *Chem.Soc.Rev.* **1988**, *17*, 229; see also: Miura, K.; Fugami, K.; Oshima, K.; Utimoto, K. *Tetrahedron Lett.* **1988**, *29*, 1543.
3. Hashimoto, S.; Shinoda,T.; Ikegami, S. *Tetrahedron Lett.* **1986**, *27*, 2885.
4. Substituted malonic acid esters are known to undergo decarboethoxylation in DMF in the presence of LiI.[5] Partial decarboethoxylation of cyclopentene 3, resulting in 15% yield of 4-methyl-3-oxabicyclo[3.3.0]oct-6-en-2-one, is observed after longer reaction time (2 h).
5. Dean, P.D.G. *J.Chem.Soc.* **1965**, 6655.
6. Molecular models of 3-5 and 8-11 were analyzed by the MM2 method[7] to give the following values for the dihedral angles H(3)-C(3)-C(4)-H(4) and for the coupling constants of protons H(3), H(4) in syn- and anti-isomers: $37-38^{\circ}$, 7.4-7.6Hz(syn-); $85-86^{\circ}$, 1.9-2.0Hz(anti-). The observed values of $J_{H(3)-H(4)}$ in the range of 6.6-7.2Hz fit the syn-configuration.
7. Allinger, N.L. *J.Am.Chem.Soc.* **1977**,*99*, 8127.
8. On the nucleophile opening of double activated alkenylcyclopropanes, see review: Danishefsky, S. *Acc.Chem.Res.* **1979**, *12*, 66; see also: Schultz, A.G.; Godfrey, J.D. *J.Am.Chem.Soc.* **1980**, *102*, 2414; Hiyama, T.; Morizawa, Y.; Yamamoto, H.; Nozaki, H. *Bull.Chem.Soc.Jpn.* **1981**,*54*, 2151; Burgess, K. *Tetrahedron Lett.* **1985**, *26*, 3049; Burgess, K. *J.Org.Chem.* **1987**, *52*, 2046.
9. Parker, A. *Adv.Physical Org.Chem.* **1967**, *5*, 173; Gutmann,V. *Angew.Chem.* **1967**, *79*, 279.
10. Cyclization of enolate A to cyclopentene is rather an unfavorable reaction of the 5-endo-trigonal pattern.[11]
11. Baldwin, J.E. *J.Chem.Soc., Chem.Commun.* **1976**, 734.

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