Tetrahedron Letters No. 41, pp 3945 - 3948.
©Pergamon Press Ltd. 1979. Printed in Great Britain.

0040-4039/79/1008-3945$02.00/0

SYNTHESIS AND THERMOLYSIS OF TRIMETHYLSILYL ENOL ETHERS OF 2-NORBORNANONES : AN EFFICIENT ROUTE TO CYCLOPENTENONES

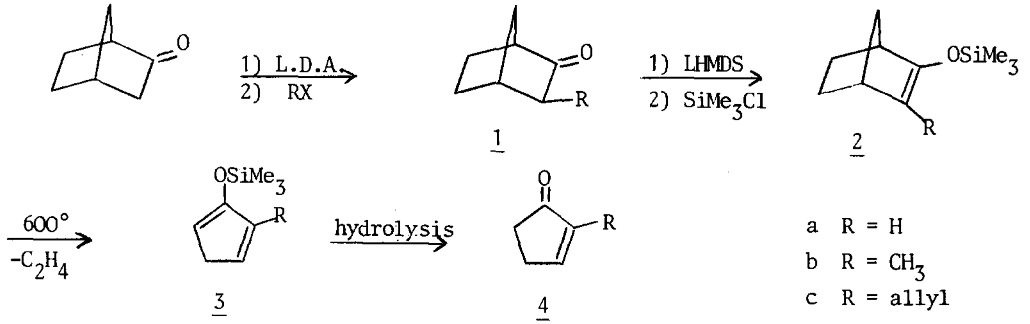
by R. Bloch

Laboratoire des Carbocycles, ERA 316, Université de Paris-Sud
Bâtiment 420, 91405 ORSAY, France

Summary. Thermolysis of silyl enol ethers of carbonyl compounds give 2-silyloxy-1,3-dienes which, after hydrolysis, lead easily to α,β-unsaturated ketones; an application to the synthesis of 2-alkyl-2-cyclopenten-1-ones is reported.

During the last past years, the reverse Diels-Alder reaction (adduct ⟶ diene + dienophile) has found wide applications in organic synthesis$^{(1)}$, particularly for the preparation of olefinic compounds (dienophile). Except for the obtention of some aromatic products, the diene component has been often neglected. However if the diene, which is formed, included an enol ether double bond, a simple hydrolysis should lead to α,β-unsaturated carbonyl compounds. We wish to report herein the results obtained by the thermolysis of silyl enol ethers of 2-norbornanones which affords a short and efficient route to 2-substituted 2-cyclopenten-1-ones, the synthesis of which remains an area of great interest to the organic chemist (2)

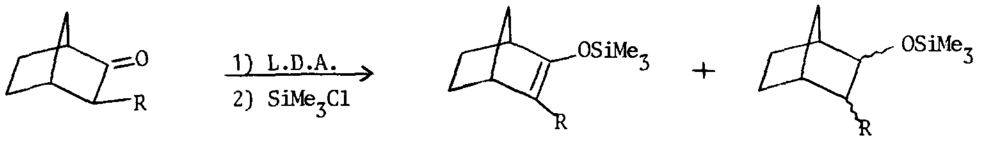
The synthesis of 2-substituted 2-cyclopenten-1-ones 4 was carried out by the following simplified scheme, starting from bicyclo [2.2.1]-heptan-2-one (2-norbornanone) :



a R = H
b R = CH_3
c R = allyl
d R = n-pentyl

Ketones 1 are easily accessible by alkylation of commercially available 2-norbornanone : the lithium enolate, generated in tetrahydrofuran from lithium diisopropylamide and 2-norbornanone, was reacted with a small excess of the halide RX in the presence of one equivalent of hexamethylphosphoramide$^{(3)}$. In all the cases the alkylation proceeded with high stereoselectivity to give the isomer coming from an exo attack of the enolate ion$^{(4)}$.

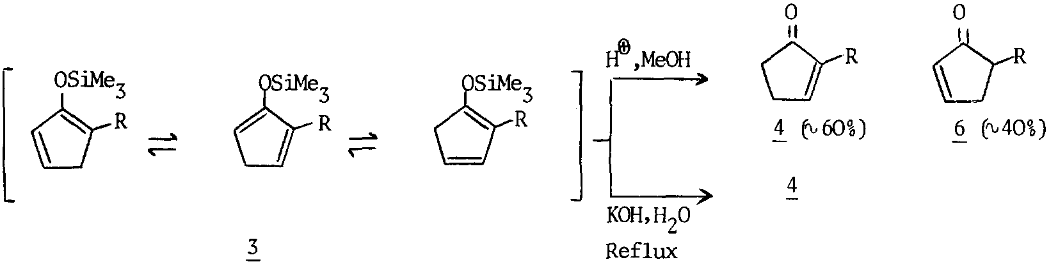
The reactions of ketones 1 with lithium diisopropylamide were quite surprising since, after quenching with trimethylchlorosilane, two products were formed : the first one came from the enolization and the other one from the unexpected reduction of the carbonyl group (5) :



1 2 5

The reduction by L.D.A. of ketones bearing α-halo and α-methoxy substituents has been very recently reported(6) but these compounds exhibited no clear feature which explained the competition between enolization and reduction. In our case it seems that the substituent R plays an important part in this competition since more reduction is observed as the size of R is increased (0 % for R = H; ∿ 10%, for R = CH_3; up to 40%, for R = n-pentyl). We were able to avoid the reduction by the use of lithium hexamethyldisilazide (LHMDS) and good yields were obtained for the formation of enol ethers 2 (see Table).

The thermal step(7) appeared to be complicated by the rearrangement of the cyclopentadiene 3, giving rise, after successive [1,5]-hydrogen shifts to a mixture of isomers(8):

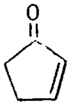
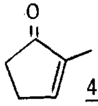
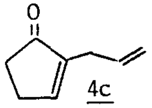
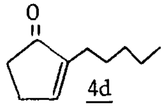
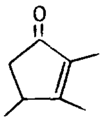


However if acidic methanolysis of the mixture 3 led to 2-and 5-substituted-2-cyclopenten-1-ones 4 and 6 (3-cyclopenten-1-ones were never observed), basic hydrolysis(9) afforded uniquely the 2-substituted isomers 4.

Extension of this reaction to the preparation of alicyclic α,β-unsaturated ketones was very attractive since the stereoselective syntheses of either the "thermodynamic" or the "kinetic" silyl enol ethers of cyclohexanones are now well documented(11) : the thermolyses of these enol ethers could lead respectively and selectively to the α-methylene ketones 7 and to the vinyl ketones 8

The results were however rather disappointing : the high temperatures required in these cases for the retro Diels-Alder rupture, generated secondary reactions and lowered dramatically the yield of unsaturated enol ethers : 60% to 65% for R = H, CH_3 but less than 10% for R = n-propyl, allyl.

Table - Preparation of cyclopentenones from 2-norbornanones (a)

Starting - Ketones -	Yield of 2 (b)	Yield of 3 (c)	Final Products (d)	
			Structure	Yield
1 a	77%	95%	 4a	85%
1 b	71%	90%	 4b	84%
1 c	72%	80%	 4c	75%
1 d	78%	90%	 4d	89%
Camphor	81%	80% (e)		70%

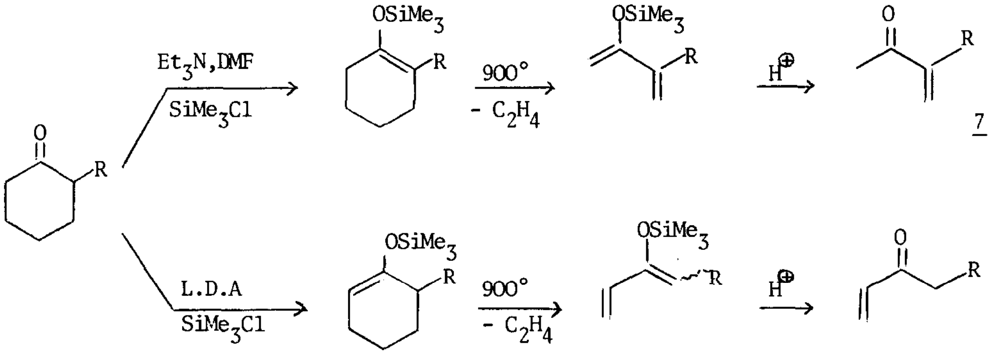
(a) All new compounds identified by N.M.R., I.R.

(b) Yield of isolated products (distillation or column chromatography)

(c) Isomeric enol ethers 3 were not separated - Thermolyses experiments were conducted at 600° (total conversion of 2). 0,01 mole of 2 were used for preparative experiments.

(d) Obtained from 3 by action of 0,5% KOH aqueous solution under reflux(9).

(e) The enol ethers observed were arising from the migration of one of the geminal methyl groups of the initially formed enol ether(10).



7

8

In summary, 2-substituted-2-cyclopenten-1-ones are readily available by thermolysis of silyl enol ethers of 3-substituted-2-norbornanones. For example, the cyclopentenone 4 d, an useful intermediate fcr the syntheses of jasmonoids(2 b,c,e) can be obtained in 35% overall yield from commercial 2-norbornanone.

References and Notes

(1) For a recent review see J.L. Ripoll, A. Rouessac and F. Rouessac, Tetrahedron, 34, 19 (1978).

(2) a) Review : R.A. Ellison, Synthesis, 397 (1973); b) S. Torii, H. Tanaka, T. Kudai and S. Watanabe, Chem. Lett., 147 (1979); c) R.F. Abdulla and K.H. Fuhr, J. Org. Chem., 43, 4248 (1978); d) P.E. Sum and L. Weiler, Can. J. Chem., 56, 2301 (1978); e) J. Tsuji, Y. Kobayashi and I. Shimizu, Tetrahedron Lett., 39 (1979).

(3) In the case of unreactive halides such as n-pentyl iodide, besides the alkylated ketone (60% yield) was observed the formation of 20% of a ketol arising from the self condensation of the starting ketone.

(4) E.J. Corey, R. Hartmann and P.A. Vatakencherry, J. Amer. Chem. Soc., 84, 2611 (1962).

(5) The reactions were conducted at-45° in THF.

(6) C. Kowalski, X. Creary, A.J.Rollin and C. Burke, J. Org. Chem., 43, 2601 (1978)

(7) Thermolyses were carried out in an apparatus analogous to the one described in the following reference : J.F. King, P. de Mayo, C.L. Mc Intosh, K. Piers and D.J.H. Smith, Can. J. Chem., 48, 3704 (1970).

(8) S. Mc Lean and P. Haynes, Tetrahedron, 21, 2329 (1965).

(9) G. Stork, G. Nelson, F. Rouessac and O. Gringore, J. Amer. Chem. Soc., 93, 3091 (1971)

(10) For analogous isomerisations see J.W. de Haan and H. Kloosterziel, Rec. Trav. Chim., 89, 1954 (1965).

(11) I. Paterson and I. Fleming, Tetrahedron Lett., 995 (1979) and references therein.

(Received in France 27 July 1979)