Tetrahedron Letters,Vol.24 No.19,pp 1971-1974,1983 0040-4039/83/191971-04$03.00/0
Printed in Great Britain

Palladium Catalyzed Cyclization of 1,5-Bismethylenecyclooctane Application to One Carbon Ring Enlargement

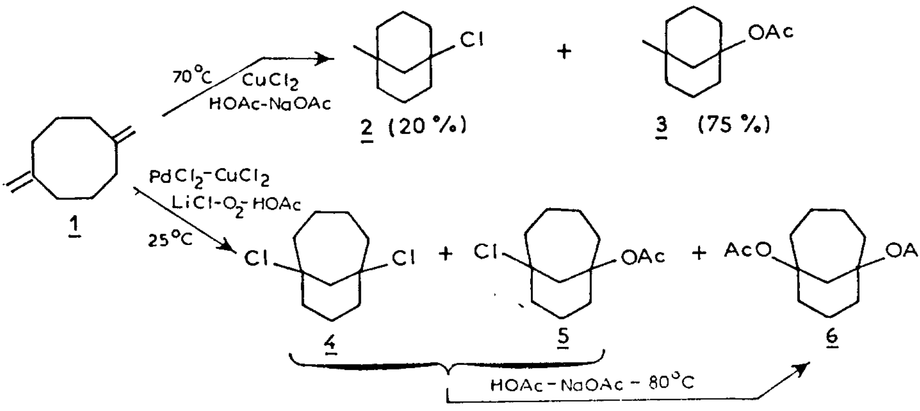
A.Heumann, M.Réglier and B.Waegell

Laboratoire de Stéréochimie, associé au CNRS (109)
Université d'Aix-Marseille III
Centre de Saint-Jérôme, 13397 MARSEILLE Cédex 13 France.

Summary : 1,5-Bismethylene cyclooctane 1 *is transformed in a one pot multi step sequence to bridgehead substituted bicyclo[4.3.1] decane derivatives by a catalytical* Pd^{II} *mediated oxidation reaction. A regioselective Wagner Meerwein rearrangement leading to ring enlargement is involved. The major product* 5 *can be fragmentated to a nine membered ring.*

The intermediary formation of a carbon-palladium σ-bond and ulterior reactions with unsaturated substrates represent a powerful method of C-C bond formation 1). Both reaction steps together with a demetallation reaction can be operative when - in the presence of nucleophiles, palladium-II salts and copper-II-chloride - non conjugated dienes are oxidized to cyclized and difunctionalized substrates 2). In the case of α,α' substituted ethylene (exomethylene) derivatives, this unequivocal palladation - cyclization sequence was surprising since such olefines are known to form Pd-π-allyl complexes 3) and mainly allylic acetates 4) as organic reaction products ; additionally under catalytic conditions analogous to the Wacker process - ring expansion reactions of methylenecyclobutanes and related systems have been described 5). As both reaction types are synthetically important, we started a study on the palladium catalysed oxidation of non conjugated bisexomethylene cycloalkanes. The possibility of chelate assisted formation of an organopalladated intermediate and subsequent insertion reactions or/and rearrangements made these kind of olefins particularly interesting. We report now preliminary results relative to the reactivity of 1,5-bismethylene cyclooctane 1 in the presence of the $PdX_2/HOAc/CuX_2$ system.

It is known that 1 can be transformed easily into bridgehead substituted bicyclo[3.3.1]octane derivatives by the action of electrophiles such as HCl,Br_2,H_2SO_4 ...6)7). A similar result is obtained when 1 is treated with $CuCl_2$ in buffered acetic acid (entry 1). However the product composition changes completely when catalytic amounts of a palladium-II-salt ($PdCl_2$, $Pd(OAc)_2$, $Pd(acac)_2$) are added to the reaction mixture. The compounds 2 and 3, derived from "Lewis Acid catalyzed" cyclization, become minor products and disubstituted bicyclo[4.3.1]decane derivatives 4 and 5 are formed instead (entry 2). Their structures have been confirmed by transformation into 6[8] and by spectroscopical data[9]. The yields of 4 and 5 can be significantly improved by lowering the temperature and by using Pd(OAc)$_2$ and Cu(OAc)$_2$ (entries 4,5 and 6).



Table

entry	catalyst[a)]	temp.	time	reaction products[b,c)] 1	2	3	4	5	6	n.i.
1	- CuCl$_2$	70°	15h	-	20	75	-	-	-	5
2	PdCl$_2$-CuCl$_2$(2mM)	70°	20h		3	18	26	26	10	17
3	PdCl$_2$-CuCl$_2$, LiCl(2mM)	70°	16h		6	56	13	14	10	1
4	PdCl$_2$-CuCl$_2$, LiCl(2mM)	25°	48h		4	11	34	41		10
5	Pd(OAc)$_2$-CuCl$_2$,LiCl(2mM)	25°	48h		2	6	34	49		9
6	Pd(OAc)$_2$-Cu(OAc)$_2$xH$_2$O Ac$_2$O,LiCl(2mM)	25°	20h			3	23	56		18
7	PdCl$_2$-CuCl$_2$,LiCl(1mM)	25°	48h	25		12	15	29		19
8	PdCl$_2$-CuCl$_2$,LiCl(5mM)	25°	24h	10	31	31	16	7		5

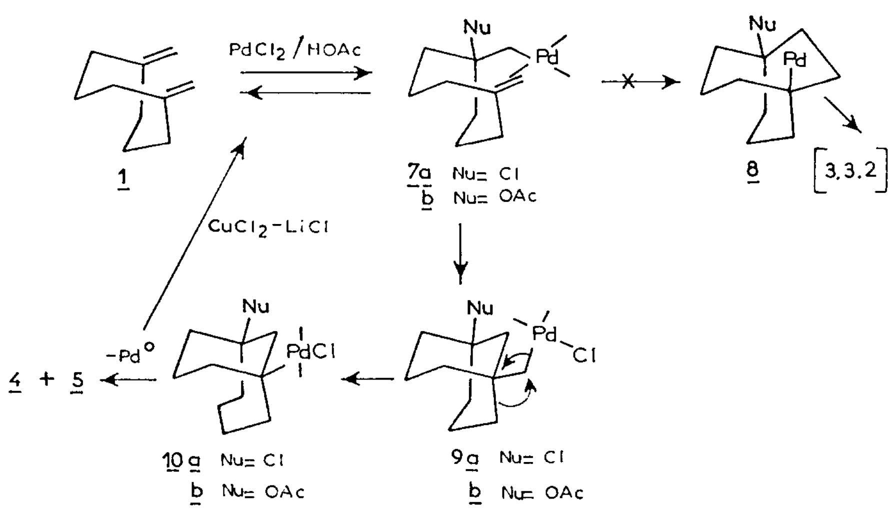
a) *reaction conditions : olefin 1mmole, Pd^{II}-salt 0,026-0,028 mmole, Pd:Cu=1:10 (exception entry 2), NaOAc-HOAc (32g/l) 2,5ml ; most of the reactions (entries 3-8) have been carried out under a pure oxygen atmosphere*

b) *chemical yield 70-80% ; g.l.c. analysis : OV1 or CW 20M glasscapillary column (50m, 80-150°).*

c) *all new compounds have been isolated by column chromatography (silicagel) and gave satisfactory elementary analysis and mass spectra.*

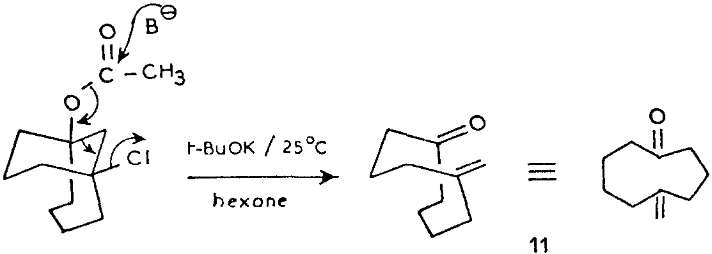
But when both palladium (oxidant) and copper salts (reoxidant) are used in catalytic quantities (entries 3-8) the addition of LiCl becomes necessary in order to form the chlorinated products 4 and 5 [10]. An appropriate amount of LiCl is required to obtain good yields of these compounds. In the case of lower LiCl concentration (1 equivalent LiCl, entry 7) we can immediately observe a lower concentration of 4 and 5 and an increased formation of 2 and 3 due to the non oxidative $CuCl_2$ catalyzed cyclization reactions. Likewise in the case of a very high LiCl concentration (entry 8) the palladation-oxidation is considerably slowed down. We also observed that phosphines - added to the reaction mixture in view of a potentiel asymmetric induction - block the palladation of 1 completely.

The cyclization of 1 into 2 and 3 in the presence of $CuCl_2$ can be rationalized on the basis of previous work 11). The formation of 4 and 5 can be explained by the following sequence :



After coordination olefin 1 reacts with $PdCl_2$ to a (stabilised) complex 7 which after the insertion reaction leads to the σ-complex 9. The insertion of an alkene into a metal σ-bond is known to be a cis process 12). As a consequence complex 8, which is another possible cis insertion product from 7 and, having the palladium located inside of the bicyclo[3.3.2] decane skeleton, should be disfavoured. Compound 9 undergoes a Wagner Meerwein rearrangement to form 10 which after reductive elimination leads to 4 and 5. The rearrangement of (1-bicyclo[3.3.1]nonyl)-methyl ions having a structure similar to 9 has been described and gives derivatives of bicyclo[4.3.1]decane and bicyclo[3.3.2]decane 13). Comparable to other palladium catalysed rearrangements of olefins which proceed with high regio- and stereoselectivity 14), the transformation of 1 shows the very specific character of a C-Pd bond in carbenium ion like transpositions, compared to classical ionic rearrangements. Apparently no intermediate is formed, which could lead (as observed in ionic reactions) to a bicyclo[3.3.2]decane system.

Due to their rigid structure compounds like 4 and 5 may be valuable for further transformations. For example 5 can be fragmentated 15) in the presence of bases to a functionalized nine membered ring compound 11.



5

11

This regiocontrolled synthesis of 11 by a 2 step palladation fragmentation process and including a one carbon ring enlargement$^{16)}$ might by a new and interesting entry into the cyclononane ring system. In contrast to cyclooctanes which are now easily accessible - in an industrial scale - by nickel catalysed cycloaddition reactions$^{17)}$, the chemistry and synthesis of higher homologues, more precisely the nine, ten and eleven membered rings are still much less developped. The elaboration of our oxidative-palladium catalysed cyclization to other (higher) bismethylene cycloalkanes is in progress.

References :

1 - a)P.M.Henry "Palladium Catalyzed Oxidation of Hydrocarbons" D.Reidel, Dondrecht, Boston, London 1980 ; b) J.Tsuji, "Organic Synthesis with Palladium Compounds"Springer Berlin 1980.
2 - A.Heumann, M.Réglier, B.Waegell, Angew.Chem.Int.Ed.Engl.,1979,18,866+867.
3 - reference 1a) p.268.
4 - K.Kikukawa, K.Sakai, K.Asada, T.Matsuda, J.Organomet.Chem., 1974, 77, 131 ; Y.Castanet, F.Petit, J.Chem.Res.(S) 1982, 238(M) 2401.
5 - P.Boontanonda, R.Grigg, J.C.S.Chem.Commun., 1977, 583.
6 - R.Bishop, J.C.S.Perkin I 1974, 2364.
7 - The formation of another (rearranged) bicyclic system, the bicyclo[3.3.2] decane ring from 1, K.H.Baggaley, W.H.Evans, S.H.Graham, D.A.Jonas, D.H.Jones, Tetrahedron 1968, 24, 3445, has been questioned$^{6)}$.
8 - P.Warner, W.Boulanger, Tetrahedron Letters, 1980, 21, 123. Compound 6 can be obtained by NaOAc buffered acetolysis of 4 and 5 ; 5 days at 80°C.
9 - 4 : ^{1}H-NMR δ:2.30(d,J=12Hz,1H);2.88(d,J=12Hz,1H);1.50-2.30(m,14H). ^{13}C-NMR 71.65(s),52.72(t),41.53(t),39.83(t),22.85(t),21.35(t).5:IR 1730cm^{-1} ^{1}H-NMR δ3.15(d,J=12Hz,1H),1.98(s,3H),1.40-2.40(m,14H),^{13}C-NMR 170.04(s), 84.93(s),72.73(s),47.80(t),45.29(t),41.87(t),37.76(t),37.63(t),25.55(t), 23.41(t),22.40(t),21.63(q).
10 - As known for ethylene a high chloride concentration is needed to favour the formation of disubstituted products:(reference 1a) p.93).
11 - A.Heumann,B.Waegell, Nouv.J.Chim., 1977, 1, 275.
12 - G.Henrici Olivé, S.Olivé, Fortschr.Chem.Forsch., 1976, 67, 107.
13 - a) S.H.Graham, D.A.Jonas, J.Chem.Soc.(C) 1969, 188 ; b) cf.also : V.Golzke, H.Langhals, C.Rüchardt, Synthesis, 1977, 675.
14 - W.C.Baird, J.Org.Chem., 1966, 31, 2411. G.R.Wiger, M.F.Rettig, J.Amer.Chem. Soc.,1976,98,4168;R.M.Giddings,D.Whittacker,Tetrahedron Letters,1978,4077; T.Sasaki, K.Kanematsu,A.Kondo,J.C.S.Perkin I 1976,2516 ;Y.Ito,H.Aoyama, T.Saegusa, J.Amer.Chem.Soc., 1980, 102,4519.
15 - A recent example of a fragementation leading to functionalized medium ring systems:M.E.Garst,V.A.Roberts,C.Prussin,J.Org.Chem.,1982,47,3969.
16 - Review : H.Heimgartner Chimia 1980, 34, 333.
17 - B.Bogdanovic, Adv.Organomet.Chem. Vol.17 Academic Press, New-York, 1979, p.105.

(Received in France 4 February 1983)