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Study on Nucleophilic Additions to *endo*-tricyclo[5.2.1.0^{2,6}]deca-2(6),8-dien-3-one and an Unusual Payne Rearrangement of α, β-Epoxy Tricyclodecenone

Xue Shi MAO*, A.A. VOLKERS[1], A.J.H. KLUNDER[1], Binne ZWANENBURG[1]

[1]Department of Organic Chemistry, NSR Center for Molecular Structure, Design and Synthesis, University of Nijmegen, Toernooiveld 1, 6525 ED Nijmegen, The Netherlands

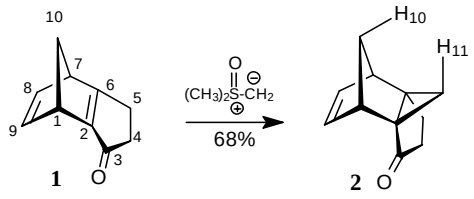
Abstract: Synthesis of highly strained tetracyclic ketones was achieved by cyclopropanation or epoxidation of tricyclodecenone **1.** An unusual formation of α-methoxy β-hydroxy ketone from an α,β-unsaturated enone system *via* Payne rearrangement was reported.

Keywords: Nucleophilic addition, Payne rearrangement, α,β-epoxycyclopentanone.

The facial selectivity of nucelophilic additions to *endo*-tricyclo [5.2.1.0^{2,6}] deca-2(6),8-dien-3-one **1** demonstrates a high preference for *exo*-facial attack to the enone moiety[1]. We were interested in whether it would be possible to accomplish three–ring annulation to tricyclodecenone **1** by cyclopropanation or epoxidation. Three-ring annulation would lead to an increase in total ring strain as compared with the starting enone, not as previous nucleophilic addition reactions which release strain energy.

We applied dimethylsulfoxnium ylide as cyclopropanation reagent for **1**. The result is satisfactory. We obtained the cyclopropanation product **2** in 67% yield with complete *exo*-facial stereoselectivity (**Scheme 1**). The structure of **2** was determined by 2D NOESY NMR, which showed a strong NOE contact between H_{10} and H_{11}.

Scheme 1

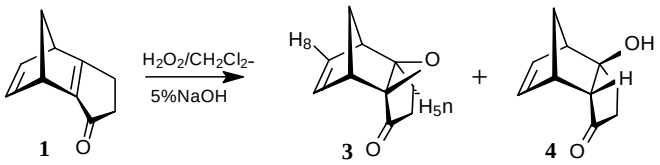


We also tested the epoxidation reaction of **1.** When the reaction proceeded using H_2O_2 (30% aq.) as the reagent in CH_2Cl_2 (in the presence of 5% NaOH), the desired epoxidation product **3** was obtained in 61% yield (**Scheme 2**). The hydroxide anion

* Present address: Institute of Materia Medica, Chinese Academy of Medical Sciences & Peking Medical College, 1 Xian Nong Tan Street, 100050

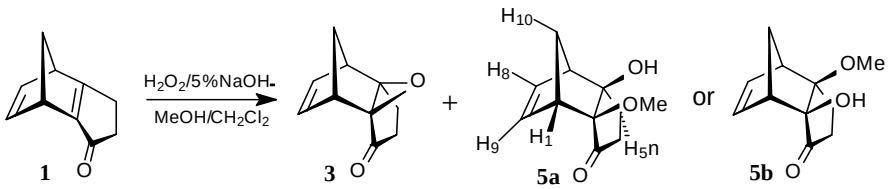
addition product 6-Hydroxytricyclodecenone **4** was also obtained in 19% yield as a byproduct. The stereochemistry of **3** was also resolved by 2D NOESY NMR technique showing a NOE contact between H_{5n} and H_8 protons in the norbornene moiety.

Scheme 2



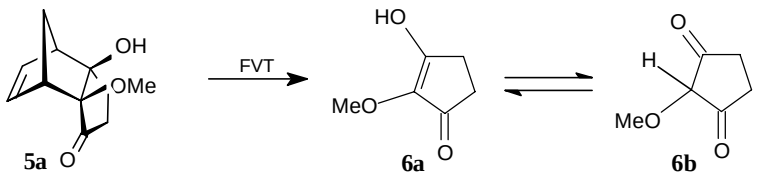
However, the interesting result was obtained when methanol was used as co-solvent during the epoxidation reaction of **1**. In addition to product **3**, a new product **5** was isolated in 85% yield. ^1H, ^{13}C NMR and MS spectral analysis[6] indicates **5** contains one hydroxy group and one methoxy group instead of epoxide ring at the central double bond (**Scheme 3**). But no clear evidence was obtained about the definite position of either these functionalities.

Scheme 3



However, extensive analysis of 2D NOESY NMR spectra indicates a NOE contact between H_8 and H_{5n}. Usually H_8 and H_{5n} show a clear NOE contact, but in this case the chemical shifts of H_{10} and H_{5n} are identical. Although H_{10} always has NOE interaction with H_8, the cross peak between H_{10} and H_8 is larger than H_{10} and H_9 in the 2D NOESY spectra. It suggests an additional NOE contact between H_8 and H_{5n}. Because of this observation the other hydrogens in the norbomene system were assigned and a NOE contact was also found between H_1 and the hydrogens of the methoxy group. Therefore, the structure of the new product is most likely to be **5a**.

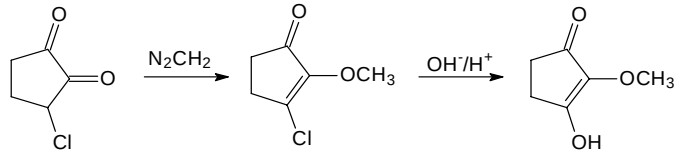
Scheme 4



For further evidence of the strcture **5a**, the flash vacuum thermolysis (FVT) experiments[2] of the new product **5a** was carried out. Cycloreversion of **5** by FVT led to a cyclopentanoid **6** with the expected mass 129 (M^++1) and a typical NMR proton spectrum. The ^{1}H NMR of **6** showed two peaks (δ 3.86, s, 3H, OMe), (δ 2.47, s, 4H, CH_2) and an broad signal (δ 4.25-5.75) for an acidic proton.

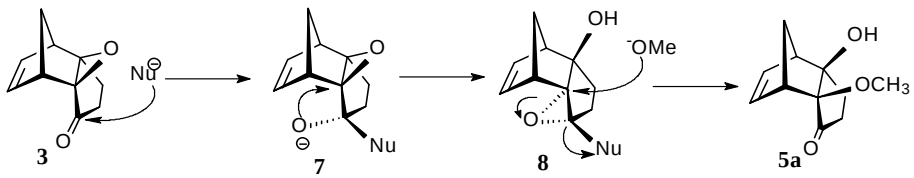
For final determination of structure of **6**, we synthesized hydroxy-2-methoxy-cyclopent-2-enone according to the reference[3] (**Scheme 5**). The result showed that the analytical data of **6** were identical with those of hydroxy-2-methoxy-cyclopent-2-enone**.** Thus the conclusion can be made that when *endo*-tricyclo[5.2.1.0^{2,6}]deca-2(6),8-dien-3-one **1** in the medium of MeOH and CH_2Cl_2 reacted with H_2O_2, the epoxide ring opening product **5a** was obtained.

Scheme 5



The new disubstituted tricyclodecenone **5a** was only obtained when methanol and hydrogen peroxide were both present. In the absence of hydrogen peroxide, the methanol addition product was formed with methanol and base only[1]. The mechanism of formation of **5a** was postulated in **Scheme 6**. The initially formed epoxide **3** is proposed to undergo a nucleophilic addition at the carbonyl group to form **7**, followed by intramolecular epoxide opening in analogy with the Payne rearrangement[4]. The obtained epoxide **8** was attacked by methoxide ion to give the desired product **5a**. Such type of Payne rearrangement was reported earlier for a tricyclodecadienone epoxide by Dols[5]. The mechanism was confirmed by treating the epoxide **3** with methoxide ion in methanol which indeed produced the disubstituted tricyclodecenone **5a**.

Scheme 6



Conclusion

Synthesis of two highly strained tetracyclic ketone was achieved by cyclopropanation and epoxidation of tricyclodecenone **1.** An unusual addtion product at the enone moiety was obtained when epoxidation was carried out in methanol. The structure of this

unusual addition product was established as **5a** on the basis of spectral evidence and the flash vacuum thermolysis experiment. The mechanism of the formation of **5a** was proposed and it was proved by additional experiment.

Acknowledgment

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References and Notes

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6. Spectra data of **5a**: ^{1}H NMR (400 MHz, $CDCl_3$, δ ppm) 6.21 (dd, 1H, *J*=5.7Hz, *J*=2.8Hz, H-8), 5.95 (dd, 1H, *J*=5.7Hz, *J*=2.8Hz, H-9), 3.76 (s, 1H, O-H), 3.57 (s, 3H, CH_3), 3.11 (br, 1H, H-1), 2.83 (br, 1H, H-7), 2.64 (m, 1H, H-4x), 2.12 (d, 1H, *J*=8.0 Hz, H-10s), 2.06 (m, 2H, H-4n, H-5x), 1.85 (m, 1H, H-5n), 1.84 (d, 1H, *J*=8.0 Hz, H-10a). ^{13}C NMR (100 MHz, $CDCl_3$, δ ppm) 215.2, 137.4, 134.7, 86.7, 83.4, 53.6, 52.7, 48.6, 43.9, 40.1, 32.8. IR ($CDCl_3$, cm^{-1}): ν 3446 (O-H), 2999 (C-H), 2959 (C-H), 1720 (C=O), 1135 (C-0). GCMS (*m/z*): 194 (1, M^+), 177 (2, M^+-OH), 129 (74, M^+-C_5H_5), 128 (100, M^+-C_5H_5-1), 66 (20, $C_5H_5^+$+1). HRMS (*m/z*): 194.094070 (M^+), Calcd. for $C_{11}H_{14}O_3$ 194.094292.

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