$(CH_2Ph)CH_2OCH_3$ (isomer 1), 90554-03-3; $CH_3(CH_2)_3CH(Et)C(OEt)=NCH(CH_2Ph)CH_2OCH_3$ (isomer 2), 90554-16-8; $CH_3CH_2CH(CH_3)C(OEt)=NCH(Ph)CH_2OCH_3$ (isomer 1), 90554-04-4; $CH_3CH_2CH(CH_3)C(OEt)=NCH(Ph)CH_2OCH_3$ (isomer 2), 90554-17-9; $CH_3(CH_2)_2CH(CH_3)C(OEt)=NCH(Ph)CH_2OCH_3$ (isomer 1), 90554-05-5; $CH_3(CH_2)_2CH(CH_3)C(OEt)=NCH(Ph)CH_2OCH_3$ (isomer 2), 90554-18-0; $CH_3(CH_2)_3CH(CH_3)C(OEt)=NCH(Ph)CH_2OCH_3$ (isomer 1), 90554-06-6; $CH_3(CH_2)_3CH(CH_3)C(OEt)=NCH(Ph)CH_2OCH_3$ (isomer 2), 90554-19-1; $(CH_3)_2CHCH(CH_3)C(OEt)=NCH(Ph)CH_2OCH_3$ (isomer 1), 90554-07-7; $(CH_3)_2CHCH(CH_3)C(OEt)=NCH(Ph)CH_2OCH_3$ (isomer 2), 90554-20-4; $PhCH_2CH(CH_3)C(OEt)=NCH(Ph)CH_2OCH_3$ (isomer 1), 90554-08-8; $PhCH_2CH(CH_3)C(OEt)=NCH(Ph)CH_2OCH_3$ (isomer 2), 90554-21-5; $CH_3(CH_2)_2CH(Et)C(OEt)=NCH(Ph)CH_2OCH_3$ (isomer 1), 90554-09-9; $CH_3(CH_2)_2CH(Et)C(OEt)=NCH(Ph)CH_2OCH_3$ (isomer 2), 90554-22-6; $CH_3(CH_2)_3CH(Et)C(OEt)=NCH(Ph)CH_2OCH_3$ (isomer 1), 90554-10-2; $CH_3(CH_2)_3CH(Et)C(OEt)=NCH(Ph)CH_2OCH_3$ (isomer 2), 90554-23-7; $CH_3CH_2CH(CH_3)C(OEt)=NCH(i\text{-}Pr)CH_2OCH_3$ (isomer 1), 90554-11-3; $CH_3CH_2CH(CH_3)C(OEt)=NCH(i\text{-}Pr)CH_2OCH_3$ (isomer 2), 90554-24-8; EtI, 75-03-6; *i*-PrI, 75-30-9; $PhCH_2Br$, 28807-97-8; CH_3I, 74-88-4; *n*-PrBr, 106-94-5; *n*-BuBr, 109-65-9; EtBr, 74-96-4.

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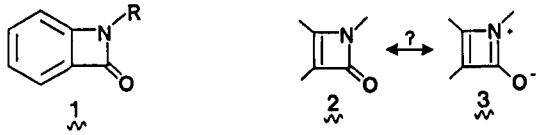
Azetinones Revealed

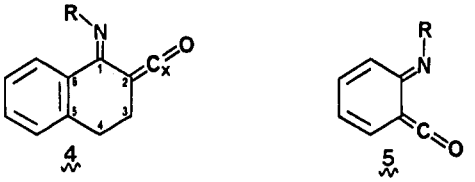
Summary: Chemical and spectral evidence for the formation of azetinones **11a–d** is presented.

Sir: While benzoazetinones **1** are known from work in this laboratory[1,2] and elsewhere,[3] no report of the synthesis of a simple azetinone (**2**) has survived the critical scrutiny

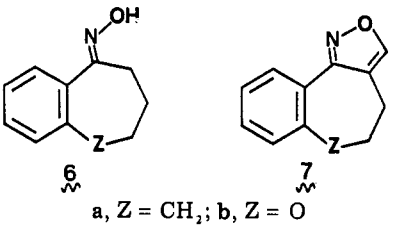


of the chemistry community. Announcements of success have been followed by disproofs,[4] and the literature is strewn with the conclusions of those who have conceded after clever attempts that **2** cannot be obtained.[5] Past interest in azetinones derives from their attractiveness as intermediates in the synthesis of medicinally useful α,β-functionalized β-lactams. As potentially antiaromatic compounds (**2** ↔ **3**), which can avoid violating Hückel's rule by bending R out of the ring plane, azetinones also are of theoretical importance.[6]

The present investigation was prompted by a hint that imino ketene **4** was generated in the chemistry of the related isoxazolium salt[7] and from indications that in solution **5** is a trace component in equilibrium with the benzoazetinone (**1**).[8] Thus, if N and C_x could be pushed together by pulling C_2–C_3 and C_1–C_6 apart while retaining the *s*-cis relationship at C_1–C_2, an azetinone might be observed.



To this end, the known *E* oximes[9] **6a,b** were converted to the respective isoxazoles (**7a**, C_3H at δ 8.15,[10] 77% yield; **7b**, δ 8.07, 74%) by the general acylation–cyclization process of Barber and Olofson.[11] These were alkylated either with a strong electrophile (CF_3SO_3Me or FSO_3Et) or with *t*-ROH/HX[12] to give the isoxazolium salts (**8a**, C_3H at δ 9.02, 94% yield; **8b**, δ 8.91, 6%; **8c**, δ 9.03, 92%; **8d**, δ 8.99, 9%; **8e**, δ 9.06, 24%; **8f**, δ 9.17, 90%). The latter process failed in the attempted *tert*-alkylation of **7b**.



a, Z = CH_2; b, Z = O

Treatment of **8** consecutively or simultaneously with tertiary amines and nucleophiles (MeOH or Et_2NH) nicely afforded the ring-opened products (**9a**, IR C=O at 6.15 μm; **9b**, 6.11; **9c**, 6.23; **9d**, 6.09) expected from addition of the nucleophile to an azetinone (**11**) or its assumed[8] imino ketene precursor (**10**). The anhydride (**9e**, C=O at 166.7 ppm) was obtained on reaction of **8f** with dicyclohexylethylamine (Cy_2NEt) in the presence of trace water.

When anhydrous *i*-Pr_2NEt (1 equiv) was rapidly added to the *N*-ethyl salt **8a** in scrupulously dried CH_2Cl_2 kept at 5 °C, a bright yellow color instantly appeared. The solution immediately was analyzed by IR (cells dried in vacuo and stored at 5 °C). The spectrum contained a strong, short-lived C=O stretch absorption in the 5.5–5.6 μm range expected for the azetinone (**11a**, gone in ca. 4

(1) Olofson, R. A.; Vander Meer, R. K.; Hoskin, D. H.; Bernheim, M. Y.; Stournas, S.; Morrison, D. S. *J. Org. Chem.* **1984**, in press. First isolation: Olofson, R. A.; Vander Meer, R. K.; Stournas, S. *J. Am. Chem. Soc.* **1971**, *93*, 1543.

(2) Vander Meer, R. K.; Olofson, R. A. *J. Org. Chem.* **1984**, in press.

(3) Bashir, N.; Gilchrist, T. L. *J. Chem. Soc., Perkin Trans. 1* **1973**, 868. Burgess, E. M.; Milne, G. *Tetrahedron Lett.* **1966**, 93. Ege, G. *Chem. Ber.* **1968**, *101*, 3079. Ege, G.; Pasedach, F. *Ibid.* 3089.

(4) Recent publications where investigators have nicely disproved azetinone structures presented by earlier workers include: Gane, P. A. C.; Boles, M. O. *Acta Crystallogr., Sect. B* **1979**, *B35*, 2664. Bachi, M. D.; Goldberg, O.; Gross, A.; Vaya, J. *J. Org. Chem.* **1980**, *45*, 1481. Abdulla, R. F.; Unger, P. L. *Tetrahedron Lett.* **1974**, 1781. While Henery-Logan and Rodricks [Henery-Logan, K. R.; Rodricks, J. V. *J. Am. Chem. Soc.* **1963**, *85*, 3524] have not been retracted, it is unlikely that 1,2-diphenyl-2-azetin-4-one is correctly described therein. The product had mp of 121 °C after *chromatography over alumina* and crystallization from acetone–*water* (IR CO stretch at 5.71 μm).

(5) For example: Barton, D. H. R.; Buschmann, E.; Haüsler, J.; Holzapfel, C. W.; Sheradsky, T.; Taylor, D. A. *J. Chem. Soc., Perkin Trans. 1* **1977**, 1107. Allan, R. D.; Barton, D. H. R.; Girijavallabhan, M.; Sammes, P. G.; Taylor, M. V. *Ibid.* **1973**, 1182. Kretschmer, G.; Warrener, R. N. *Tetrahedron Lett.* **1975**, 1335. Sheradsky, T.; Zbaida, D. *J. Heterocycl. Chem.* **1983**, *20*, 245 and references therein. For other processes proceeding via **2**, see: Potts, K. T.; Ehlinger, R.; Nichols, W. M. *J. Org. Chem.* **1975**, *40*, 2596 and references therein.

(6) Benzoazetinone (**1**) is antiaromatic; all ring system atoms along with the attached exocyclic O and N–C are in the same plane.[1]

(7) Olofson, R.; Barber, G.; Hoskin, D., unpublished observation.

(8) The imino ketene **5** was proposed as a trace equilibrium intermediate from kinetic studies (in the dark and photochemically): Olofson, R. A.; Vander Meer, R. K. *J. Org. Chem.* **1984**, in press.

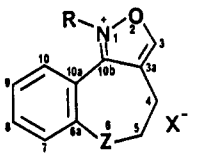
(9) **6a**: Kipping, F. S.; Hunter, A. E. *J. Chem. Soc.* **1901**, *79*, 602. **6b**: Bădilescu, I. I. *Rev. Roum. Chim.* **1975**, *20*, 761.

(10) New compounds identified by including some property (for spectral data, see supplementary material); mp **7a** 56.5–57 °C, **7b** (bp) 135–138 °C at 0.6 mm, **8a** 151–152 °C, **8b,c** solid ClO_4^- salts, **8d** 61–63 °C, **8e** 169–170 °C dec, **8f** 80–82 °C, **9b** 66.5–67.5 °C, **9c** 90.5–92 °C, **9a,d,e** oils.

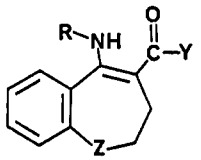
(11) Barber, G. N.; Olofson, R. A. *J. Org. Chem.* **1978**, *43*, 3015. Hoskin, D. H.; Olofson, R. A. *Ibid.* **1982**, *47*, 5222.

(12) Woodward, R. B.; Woodman, D. J. *J. Org. Chem.* **1966**, *31*, 2039. Woodman, D. J. *Ibid.* **1968**, *33*, 2397. *t*-BuOH formed in situ from isobutene.

0022-3263/84/1949-2652$01.50/0

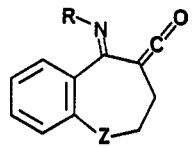


8a, Z = CH_2; R = Et; X = FSO_3
8b, Z = CH_2; R = *t*-Bu; X = ClO_4
8c, Z = CH_2; R = 1-Ad; X = ClO_4
8d, Z = CH_2; R = *t*-Bu; X = BF_4
8e, Z = CH_2; R = 1-Ad; X = BF_4
8f, Z = O; R = Me; X = CF_3SO_3



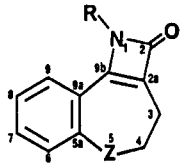
9a, Z = CH_2; Y = NEt_2
9b, Z = CH_2; R = 1-Ad; Y = OMe
9c, Z = CH_2; R = 1-Ad; Y = NEt_2
9d, Z = O; R = Me; Y = OMe
9e, Z = O; R = Me; Y = $)_2O$

min). Similar results were obtained with the *tert*-butyl salt (**8b** → **11b**, lifetime ca. 10 min) and the adamantyl salt (**8c** → **11c**, lifetime ca. 20 min).



10

a, Z = CH_2; R = Et
b, Z = CH_2; R = *t*-Bu



11

c, Z = CH_2; R = 1-Ad
d, Z = O; R = Me

FT IR studies fixed the C=O position of **11c** at 5.56 μm (vs. 5.55 μm for 1 R = 1-adamantyl[1]). Quite stable solutions of **11c** could be obtained at the lower temperatures permitted in ^{13}C NMR analysis. *i*-Pr_2NEt (1 equiv) was added to a −78 °C solution of **8c** in anhydrous 1:1 CH_2Cl_2:$CDCl_3$ in an NMR tube then placed in a probe kept at −40 °C. After 2 h, the ^{13}C NMR spectrum contained only peaks of **11c** downfield from $CDCl_3$: C_2 177.0, C_{9b} 170.5, C_{2a} 144.6, C_{5a} and C_{9a} 128.6 and 124.3, C_{6-9} 130.8, 129.1, 127.9, and 125.1 ppm.[13] After another 2 h at −20 °C, the spectrum was unchanged. However, after a few min at 25 °C, **11c** had decomposed to a mixture of products. In similar experiments with **8a** and **8f**, the solutions of **11a** (C_2 175.4, C_{9b} 166.7, C_{2a} 141.9) and **11d** (C_2 173.3) were much less stable and contaminated from the start with decomposition products.

The solutions of **11a–c** all gave complex mixtures of products unless nucleophiles were quickly added to the reaction media (→ **9**). The relative lifetimes of **11a–c** reflect steric differences in the accessibility of **11** to :Nu and probably also variations in the peri interaction with C_9H helping to keep the ring closed. In accord with this rationalization, *N*-methylazetinone (**11d**) was too unstable to detect by IR.[14]

Since **2** does not have to be isolated to be used in synthesis, a renewed future for this ring system in preparative chemistry is predicted.

Acknowledgment. We thank the NIH and McNeil Pharmaceutical for supporting this study. A.B. (U. of Calcutta) visited Penn State as UNESCO Fellow in the UNDP Special Assistance to Selected Universities Program.

Registry No. **6a**, 90695-87-7; **6b**, 57439-39-1; **7a**, 90695-88-8; **7b**, 55401-03-1; **8a**, 90695-90-2; **8b**, 90695-92-4; **8c**, 90695-94-6; **8d**, 90695-95-7; **8e**, 90695-96-8; **8f**, 90695-98-0; **9a**, 90695-99-1; **9b**, 90696-00-7; **9c**, 90696-01-8; **9d**, 90696-02-9; **9e**, 90696-03-0; **11a**, 90696-04-1; **11b**, 90696-05-2; **11c**, 90696-06-3; **11d**, 90696-07-4.

Supplementary Material Available: Spectral data for new compounds (3 pages). Ordering information is given on any current masthead page.

(13) Fourier transform NMR spectra were recorded on a Bruker Instruments WP-200 Spectrometer (50.32 MHz for ^{13}C). Coupling studies were used as an aid in making the spectral assignments.
(14) From reaction of **8f** with Cy_2NEt at −40 to +25 °C.

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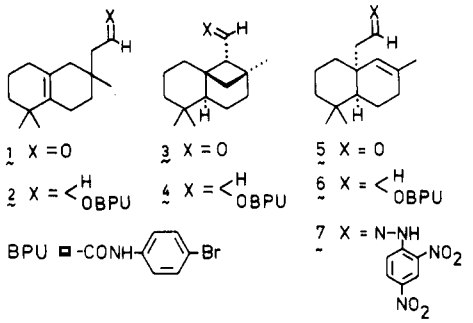
Acanthodoral and Isoacanthodoral, Two Sesquiterpenoids with New Carbon Skeletons from the Dorid Nudibranch *Acanthodoris nanaimoensis*

Summary: The structures of acanthodoral (**3**) and isoacanthodoral (**5**), two sesquiterpenoids with new carbon skeletons, have been solved by X-ray diffraction analysis of their (*p*-bromophenyl)urethane **4** and dinitrophenylhydrazone **7** derivatives, respectively.

Sir: We have recently reported that the extracts of the fragrant dorid *Acanthodoris nanaimoensis* contain three isomeric sesquiterpenoid aldehydes and we proposed a structure for the major component, nanaimoal (**1**).[1] In



this paper we report the structures of the two minor sesquiterpenoid aldehydes. The extremely small quantities (7 mg of **3**, 40 mg **5**/100 animals) and high volatility of the minor components made the efficient isolation of either pure compound extremely difficult. We therefore isolated them as their (*p*-bromophenyl)urethane derivatives.

The least abundant component, acanthodoral (**3**), gave a crystalline (*p*-bromophenyl)urethane derivative **4**: mp 109–110 °C (hexane); MS, M^+, *m/z* 421, 419, $C_{22}H_{30}BrNO_2$; ^1H NMR (400 MHz, $CDCl_3$) δ 0.81 (s, 3 H), 0.89 (s, 3 H), 0.96 (s, 3 H), 1.09 (d, 1 H, *J* = 9.2 Hz), 1.84 (d, 1 H, *J* = 9.2 Hz), 4.14 (dd, 1 H, *J* = 11.1, 6.9 Hz), 4.17 (dd, 1 H, *J* = 11.1, 7.7 Hz), 6.50 (br s, 1 H), 7.27 (d, 2 H), 7.40 (d, 2 H). The remaining 12 protons appeared as a series of complex multiplets between δ 1.2 and 1.7. Since there were no known sesquiterpenoid carbon skeletons that could account for the observed spectral data, the structure of **4** was solved by a single-crystal X-ray diffraction analysis.

Crystals of **4** belonged to the common monoclinic space group $P2_1$ with *a* = 9.581 (1) Å, *b* = 6.406 (1) Å, *c* = 34.45 (1) Å, and β = 85.85 (1)°. Two molecules of composition $C_{22}H_{30}O_2NBr$ formed the asymmetric unit. All unique diffraction maxima with $2\theta \lesssim 114°$ were collected on a computer-controlled four-circle diffractometer with a

(1) Ayer, S. W.; Hellou, J.; Tischler, M.; Andersen, R. J. *Tetrahedron Lett.* **1984**, *25*, 141.

0022-3263/84/1949-2653$01.50/0