Photo-induced Radical Rearrangements of Hypoiodite of *N*-Acetyljervine and the Related *C*-nor-*D*-Homosteroid in the Presence of Mercury(II) Oxide and Iodine[1)]

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(Received February 3, 1981)

Irradiation of the hypoiodite of *N*-acetyljervine in benzene containing mercury(II) oxide and iodine gave a mixture of products. The major product was *N*-acetyl-11-oxojerva-5,12(13)-dien-3β-yl *N*-acetyl-*A*-homo-4-oxa-11-oxojerva-5,12(13)-dien-3α-yl ether (**4**) (25%). Four minor products, *N*-acetyl-2-iodo-11-oxo-*A*-nor-2,3-secojerva-5,12(13)-dien-3-yl formate, *N*-acetyl-3α,5-epoxy-6α-iodo-*A*-homo-4-oxa-5α-jerva-5,12(13)-dien-11-one, *N*-acetyl-4-oxajerva-5,12(13)-dien-11-one, and *N*-acetyl-4-oxa-*A*-homojerva-5,12(13)-diene-3,11-dione, were also isolated. Irradiation of the hypoiodite of 3β-hydroxy-17-ethyletiojerv-5-ene-11,20-dione also gave a dimer corresponding to **4**. The formation of **4** as the major product contrasts with the result of the corresponding reaction of cholesterol.

It has been shown that hypoiodites generated from a variety of steroidal alcohols undergo heat- or light-induced reaction to give products originating through alkoxy radical intermediates.[2,3)] Mercuric oxide–iodine reagent has been shown to be an effective reagent for the formation of hypoiodites from steroidal alcohols.[4)]

In previous papers,[5–7)] we described the results of investigations of the photo- and thermally-induced rearrangements of hypoiodites of cholesterol and several related 5-cholesten-3-ols substituted with methyl groups on their C-3 and C-4 positions in the presence of mercury(II) oxide and iodine. It has been found that 3α,5-epoxy-*A*-homo-4-oxa-5α-cholestanes (type A) carrying α- or β-oriented iodine on their C-6 positions or 3α,5-epoxy-*A*-homo-4-oxa-5α-cholest-6-enes (type B) are usually formed when the reactions are induced by irradiation, although their yields varied widely; these products are usually accompanied by seco-iodide of type (C). It has also been found that methyl substituents on their C-3 or C-4 positions affect the relative yields of oxabicyclic compounds (type A) appreciably and that the presence of *gem* dimethyl group on the C-4 position results in the formation of 3-oxa-5-cholestenes (type D) with the loss of one carbon atom.[5,7)] The products from thermally-induced reactions were almost parallel, but the thermally-induced reaction of cholesterol hypoiodite gave a novel dimeric product of type (E) as the major product.[5)]

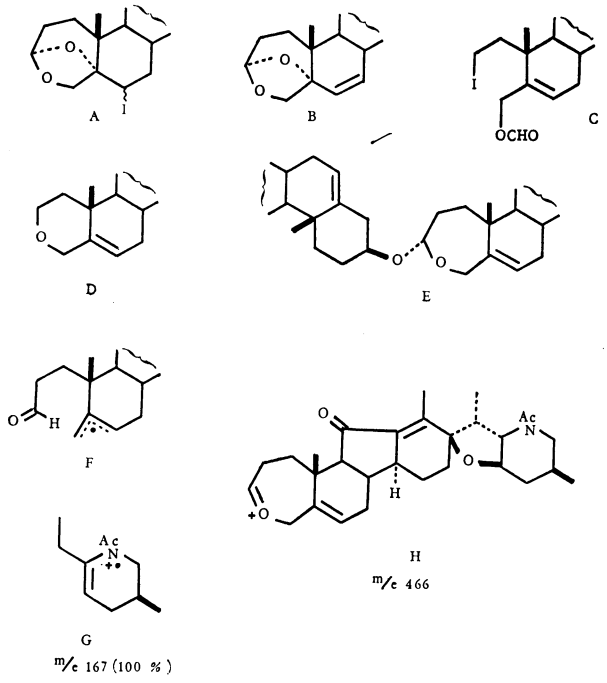
The pathways of the rearrangements which can explain the stereochemistry of these products have been advanced in the previous papers.[5–7)] All the above products are formed from an allyl radical intermediate (F) derived from β-scission of the corresponding 3β-oxyl radicals.

In this paper, we report the results of the photo-induced reaction of hypoiodite of *C*-nor-*D*-homosteroid-5-en-3β-ols in which their C-ring is 5-membered instead of 6-membered as in normal steroids.

Results and Discussion

N-Acetyljervine (**1**)[8)] and 3β-hydroxy-17α-ethyletiojerv-5-ene-11,20-dione (**11**)[9)] were chosen as the substrates. The photo-induced reactions were conducted under the conditions reported previously;[5–7)] irradiation of *N*-acetyljervine (**1**) in benzene containing mercury(II) oxide and iodine (*ca.* 3 mol equiv. each) with a 100-W high pressure mercury arc for 12 h under an atmosphere of nitrogen gave a mixture of products, from which five crystalline products (**8**) (5%), (**9**) (2%), (**6**) (1%), (**7**) (1%), and (**4**) (25%) in order of their mobility, were isolated by preparative TLC (Scheme 1). The noted yields of the products are those in pure crystalline states; thus the actual yield of each product is higher than those described above. The structures of all these products were deduced by the analysis of their spectra. The mass, IR, UV, and ^{1}H NMR spectra showed that the C, D, and heterocyclic rings in jervine were intact in all the five products.

The structure of the crystalline product (**8**) carrying iodine, which was the most mobile on the TLC plate, was proved to be *N*-acetyl-3-iodo-11-oxo-*A*-nor-2,3-secojerva-5,12(13)-dien-3-yl formate[10)] by the following spectral evidence. Although the mass spectrum showed



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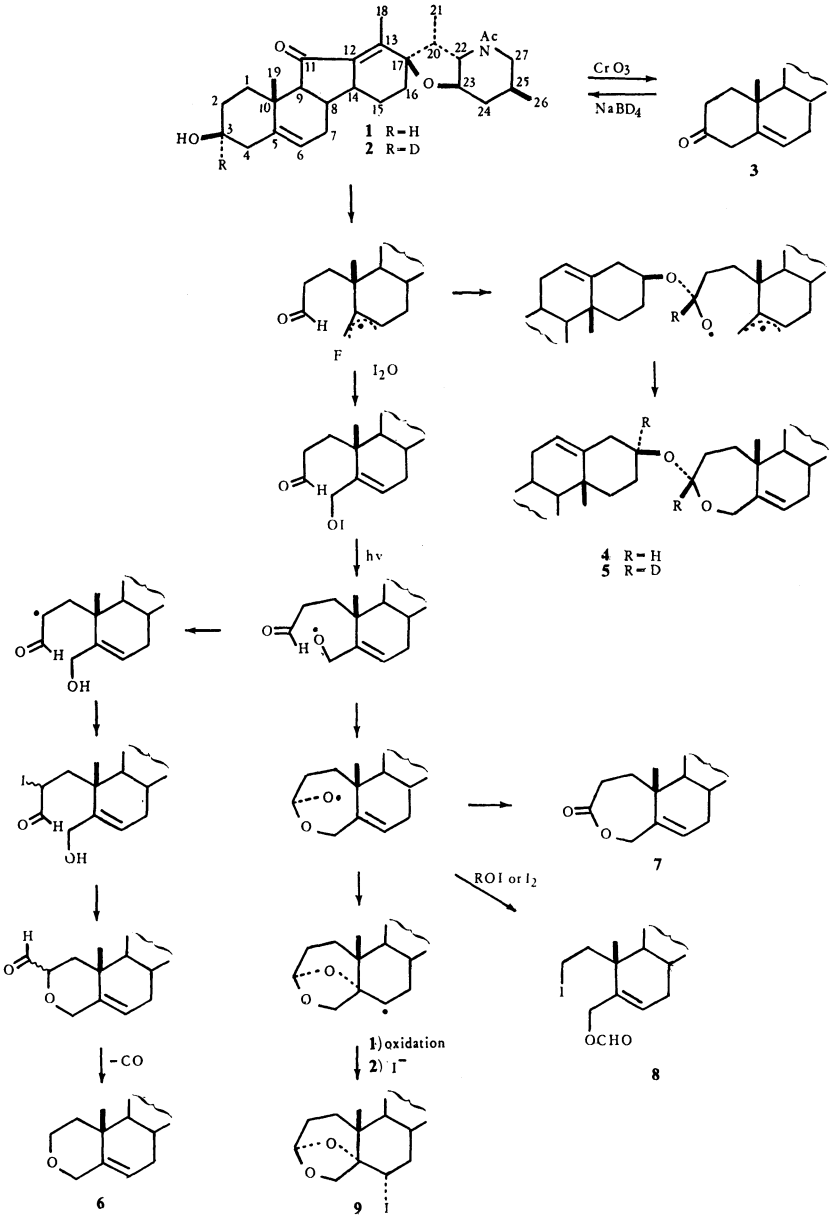


Scheme 1.

no molecular ion peak, the elemental analysis was in accord with the molecular formula $C_{29}H_{40}NO_5I$. A formate structure analogous to the formate[2] obtained from the hypoiodite of cholesterol was suggested by the presence of the 1H singlet at τ 1.91 in the ^1H NMR spectrum. The olefinic proton at the C-6 was present at τ 4.06 as a one-proton diffused doublet with J=4.5 Hz and the allylic C-3 methylene protons appeared as a broad singlet at τ 5.40 ($W_{1/2}$=5 Hz). The IR spectrum was also in agreement with the assigned structure. The pathway to this formate has already been discussed for the formation of an analogous formate from cholesterol in the previous paper.[5]

The crystalline product (**9**) carrying iodine was proved to be *N*-acetyl-3α,5-epoxy-6α-iodo-*A*-homo-4-oxa-5α-jerva-5,12(13)-dien-11-one[7] (**9**) from the following evidence: the molecular formula $C_{29}H_{40}NO_5I$ was determined by mass spectrometry (*m/e* 609, M^+) and elemental analysis. The ^1H NMR spectrum showed a broad one-proton singlet at τ 4.48, a one-proton double doublet at τ 5.55 with J=4.5 and 12.3 Hz, and an AB quartet at τ 5.84 and 6.24 with J=7.6 Hz. These signals were assigned to the 3β-H, the 6β-H, and the C-4a-methylene protons and were entirely analogous to those arising from the corresponding protons of 3α,5-epoxy-6β-iodo-*A*-homo-4-oxa-5α-cholestane[5] with respect to their chemical shifts and the coupling constants. The IR spectrum was also in accord with the assigned structure.

The molecular formula of the third TLC mobile crystalline product (**6**) was determined to be $C_{28}H_{39}NO_4$ by high resolution mass spectrometry. The structure was proved to be N-acetyl-4-oxajerva-5,12(13)-dien-11-one.[10] The ^1H NMR spectrum showed a one-proton doublet at τ 4.57 and a superimposed nine-proton multiplet (τ 5.81—7.20). The former is assigned to the olefinic 6-H and the latter is assigned to superimposed signals arising from the C-2-methylene protons, C-4-

methylene protons, 9α-H, 22β-H, 23α-H, and C-27-methylene protons. The shape of the multiplet signals is almost identical with that obtained by superimposing the signals due to 22-H, 23-H, C-27-methylene protons, and 9-H in the spectrum of *N*-acetyljervine and those due to C-2-methylene protons and C-4-methylene protons of 3-oxacholest-5-ene.[5] The IR spectrum was also in agreement with the assigned structure.

The molecular formula of the fourth TLC mobile crystalline product (**7**) was confirmed to be $C_{29}H_{39}NO_5$ by high resolution mass spectrometry. The results of the IR and NMR spectra were consistent with the structure, *N*-acetyl-4-oxa-*A*-homo-jerva-5,12(13)-diene-3,11-dione. In the IR spectrum, a new band arising from an unstrained lactone carbonyl band is present at 1737 cm^{-1}, together with the band due to the α,β-unsaturated carbonyl. In the ^1H NMR spectrum two doublets, at τ 5.36 and 5.84, and a one-proton doublet at τ 4.21 assigned to the C-4a methylene protons and the 6-H could be seen.

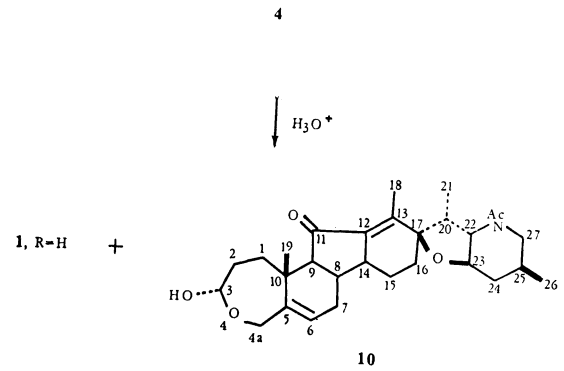
Finally, the structure of the most polar product (**4**), obtained in highest yield in this reaction, was deduced to be *N*-acetyl-11-oxojerv-5,12(13)-dien-3β-yl *N*-acetyl-*A*-homo-4-oxa-11-oxojerva-5-en-3α-yl ether, which was analogous to cholest-5-en-3β-yl *A*-homo-4-oxacholest-5-en-3α-yl ether obtained from thermal decomposition of cholesterol hypoiodite, on the basis of the spectroscopic, especially ^1H NMR spectral evidence. The molecular formula, $C_{58}H_{80}N_2O_8$, was deduced by the osmometric molecular weight determination[1] and the elemental analysis. The molecular weight was further confirmed by FD mass spectrometry, which showed the $M^+ + 1$ ion at *m/e* 933. The IR, UV, and ^1H NMR spectra proved that the C, D, and the heterocyclic ring portions of the starting jervine molecule were unchanged in this compound, as described earlier.

In the downfield region of the ^1H NMR spectrum, four signals (each one-proton) are present; these signals appeared at τ 4.45 (broad singlet), 4.69 (broad singlet), 5.12 (triplet, J=5.3 Hz) and 5.68 (doublet, J=13.5 Hz). These signals were assigned to those arising from 6-H of the *N*-acetyl-11-oxojerva-5,12(13)-dien-3β-yl portion, 6-H of the *A*-homo-4-oxa-11-oxojerva-5,12(13)-dien-3α-yl portion, and the 3β-H and 4a-H signals of *A*-homo-4-oxa-11-oxojerva-5,12(13)-dien-3α-yl portion on the basis of spin-decoupling experiments, deuterium labeling, acidic hydrolysis, and comparison of the spectrum with that of cholest-5-en-3β-yl *A*-homo-4-oxacholest-5-en-3α-yl ether.[5]

Decoupling experiments showed that the two signals at τ 4.45 and 4.69 collapsed into two clear singlets on irradiation at τ 7.5, while the triplet at τ 5.10 is only partially decoupled. The behavior of these two signals in the spin-decoupling is similar to those of C-6 olefinic proton of Δ^5-steroids. The diffused triplet at τ 5.10 was also partially decoupled to a broad singlet ($W_{1/2}$=7.0 Hz) on irradiation at τ 8.3. On the basis of an experiment which used 3α-deuterio-*N*-acetyljervine (**2**), this signal was confirmed to arise from C-3α-H of *N*-acetyljervine. 3α-Deuterio-*N*-acetyljervine (**2**) was prepared by reduction of *N*-acetyljerva-5,12(13)-diene-3,11-dione, which was prepared by the Jones oxidation of *N*-acetyljervine with $NaBD_4$. 3α-Deuterio-*N*-acetyljervine in benzene containing mercury(II) oxide and iodine was subjected to the photolysis to give a product (**5**) carrying deuterium. The ^1H NMR spectrum of **5** shows the absence of the triplet at τ 5.10 which was in the spectrum of product (**4**), proving that the triplet originated from 3α-H of the starting jervine.

The doublet at τ 5.68 in **4** was found to be a part of an AB quartet, and another doublet of the AB system superimposed with other signals was found at τ 6.48. On irradiation of the center of the doublet at τ 6.48, the doublet at τ 5.68 collapsed to a singlet. The irradiation at the center of the doublet at τ 5.68 caused a collapse of the doublet at τ 6.48 to a singlet without any change of the signal shapes at τ 4.45, 4.69 and 5.10. This AB quartet was thus assigned to an isolated C-4a methylene protons of *A*-homo-4-oxacholest-5-en-3α-yl portion.

The dimeric structure assigned to compound (**4**) was further confirmed by its acidic hydrolysis (Scheme 2).



Scheme 2.

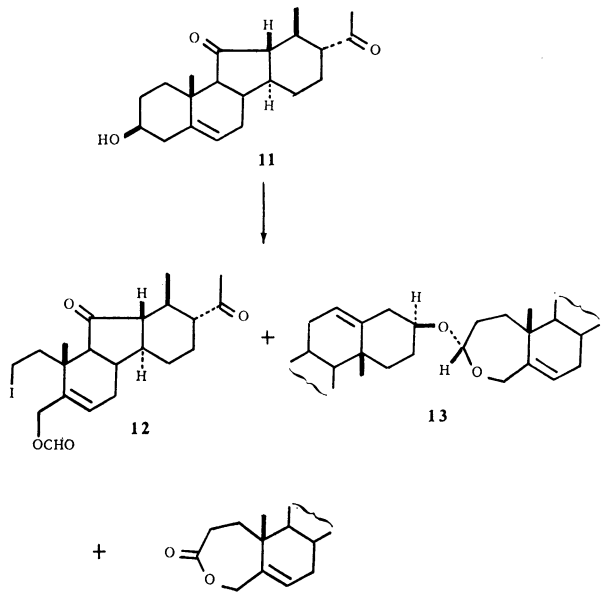
Hydrolysis of either **4** or **5** in THF containing dilute hydrochloric acid at room temperature gave only two products. As expected from the assigned structure, one of the products was found to be identical with *N*-acetyljervine (**1**) or 3α-deuterio-*N*-acetyljervine (**2**) by direct comparisons. All the spectra on the other product **10** were consistent with that of *N*-acetyl-*A*-homo-4-oxa-11-oxojerva-5,12(13)-dien-3α-ol or its 3β-deuterio compound. The MS spectrum showed the molecular ion at *m/e* 483. The IR spectrum shows the presence of a hydroxy and an α,β-unsaturated carbonyl. The ^1H NMR spectrum shows two one-proton signals at τ 4.41 and 4.86 and an AB quartet at τ 5.59 and 6.41, with J=13.3 Hz, together with a set of signals arising from the B, C and heterocyclic rings of jervine. The series of signals in the downfield region shows a remarkable similarity to the signals of compound **4** with respect to the chemical shifts and behavior in spin-decoupling. However, the spectrum shows the absence of a signal corresponding to the ones at τ 4.69 in the spectrum of compound **4**, proving that it originated from the *N*-acetyl-11-oxojerva-5,12(13)-dien-3β-yl portion.

All the foregoing results can be reconciled to the assigned structure **4**. It is noted that the signals arising from the *N*-acetyl, 18-H, 19-H, 21-H, and 26-H of the *N*-acetyl-11-oxojerva-5,12(13)-dien-3β-yl portion in the ^1H NMR spectrum were superimposed with those due

to the corresponding protons of the *N*-acetyl-*A*-homo-4-oxa-11-oxojerv-5-en-3α-yl portion.

The electron impact mass spectrum of compound **4** showed no peak above *m/e* 500 and showed weak peaks at *m/e* 465, 466, 467, and a base peak at *m/e* 167. The structures of the species of *m/e* 167 and 466 may be assigned to (G)[11] and (H). The ^{13}C FT NMR spectrum, with the aid of the off-resonance spectrum of **4**, fully supported the assigned formula. With the exceptions of the C-17 and the C-17′, the NAc and the N′Ac, and C-23 and C-23′, which appeared as the superimposed singlets at τ 172.97, 85.42, and 72.68 ppm, all the sp^2 carbon atoms and oxygen-bearing carbon atoms appeared as a pair of signals. Their assignments are as follows: C-11–CO and C-11′–CO (δ 206.65 ppm), C-5 and C-5′ (145.79 and 146.28), C-13 and C-13′ (142.46 and 144.22), C-6 and C-6′ (120.67 and 125.95), and C-3 of oxepane ring (99.08) and C-3′ (75.72).

To compare these results with those from a simpler *C*-nor-*D*-homosteroid, hypoiodite of 3β-hydroxy-17α-ethyletiojerv-5-ene-11,20-dione (**11**)[9] was subjected to the photolysis in the presence of mercury(II) oxide and iodine under the conditions described for *N*-acetyljervine hypoiodite. The results were found to be almost parallel to the case of *N*-acetyljervine (Scheme 3).



Scheme 3.

From a mixture of the products a formate (**12**), a dimer (**13**), and a lactone (**14**) were isolated in 32, 26, and 9% yields. The structures of these products were deduced by spectrometry in a manner analogous to the case of the products from *N*-acetyljervine. The results of the analysis of the spectra on each product are described in the experimental section, but the results of the electron impact mass spectrum of dimer **13** are only mentioned here. In contrast to the mass spectrum of dimer **4**, in which no molecular ion peak was present and the intensity of a fragment ion (H) was only 0.4%, that of dimer **13** showed the molecular ion peak at *m/e* 658 and the fragment ion of *m/e* 329 corresponding to the fragment (H) is the base peak. These results further supports the structure given to the product **4**. In this photolysis, two minor products (corresponding to **6** and **9**) were almost certainly present in the product mixture, but we failed to isolate these compounds in the pure forms. All the types of products, with the exceptions of lactone **7** and dimers **4** and **13**, obtained in this experiment were those already obtained in the photo-induced rearrangement of cholesterol[5] and the related 5-choleten-3-ols.[6,7] Changing the C-ring from 6-membered[5] to 5-membered, however, introduces appreciable variations in the products and their yields: dimeric acetal **4** was obtained as the major product, whereas no compound of this type was formed in the photo-induced reaction of cholesterol.[5] On the other hand, oxabicyclic compound **9** was formed in only a very minor amount although it is one of the major products in the corresponding reaction of cholesterol.[5] Unlike the cholesterol case,[5] we failed to isolate an oxabicyclic compound carrying β-oriented iodine.

The paths to dimeric acetal **4**, 4-oxa compound **6**, formate **8** and oxabicyclic compound **9** were already discussed in the previous papers.[5–7] All these products are derived from an allyl radical (F) formed by a β-scission of the 3β-oxyl radical. The Scheme 1 shows these pathways, including a path for the formation of lactone (**7**), the isolation of which in the present experiment strengthened the validity of our proposed pathways.[5] Although a further study is required for fuller understanding of origins of the variations in the products and their relative yields observed for *C*-nor-*D*-homosteroids and steroids,[5] one of the important factors would be slight changes in the geometries between groups or atoms introduced to the vicinity of the reaction center of the intermediary allyl radical. The change would affect the subtle balance between rates of intra- and intermolecular processes and would bring about appreciable differences in the products and their yields.

Experimental

For instruments used and general procedure see Ref. 2. Low resolution mass spectra of compounds, **2**, **3**, **7**—**9**, and **13** (70 eV), high resolution mass spectra of **2**, **3**, **7**, **9**, and FD mass spectra of **4**, and **5** were measured by Miss Yuko Chiba of the Faculty of Agriculture of this university. Low resolution mass spectra of compounds, **10**, **12**, and **14** (70 eV) were measured by the staff of Faculty of Pharmaceutical Sciences of this university. ^{13}C FT NMR spectra (25.1 MHz, solvent $CDCl_3$: TMS as internal reference) were determined by JEOL Ltd., Tokyo.

Irradiation of N-*Acetyljervine Hypoiodite in the Presence of Mercury(II) Oxide and Iodine.* *N*-Acetyljervine (**1**) (806 mg), mercury(II) oxide (763 mg), and iodine (1.346 g) in benzene (60 ml) in Pyrex vessel were irradiated for 12 h with a 100-W high pressure mercury arc under a nitrogen atmosphere. After the solution was filtered, the filtrate was evaporated to give a residue which was dissolved in chloroform. The chloroform solution was washed with 5% sodium thiosulfate solution and water (twice), and dried over anhydrous sodium sulfate. After the usual work-up, the residue was subjected to preparative TLC (SiO_2) with a chloroform–diethyl ether (10 : 1). Five products: **8**, **9**, **6**, **7**, and **4**, in order of their increasing mobility in TLC, were obtained. The product **8**, which was

the most mobile on the TLC plate, was recrystallized from ethanol to yield crystals (52 mg), mp 159—160.5 °C. The Beilstein test was positive. Found: C, 56.77; H, 6.64; N, 2.37%. Calcd for $C_{29}H_{40}NO_5I$: C, 57.12; H, 6.62; N, 2.30%. IR, 1719 and 1672 (α,β-unsaturated carbonyl), 1751 (formate carbonyl), 1627 (*N*-acetyl), 1176 (formate C=O), 895, and 840 cm^{-1}; NMR, τ 1.91 (1H, s, formate), 4.06 (1H, d, J=4.5 Hz, 6-H), 5.40 (2H, s, $W_{1/2}$=5 Hz, CH_2–OCHO), 7.75 (3H, s, 18-H), 7.90 (3H, s, N-Ac), 9.95 (3H, d, J=6, 21-H), 8.99 (3H, s, 19-H), and 9.13 (3H, d, J=7.5 Hz, 26-H); MS, *m/e* (rel intensity), 435 (1.9), 156 (100), and 114 (27.7).

Product **7** was recrystallized from acetone to yield crystals (21 mg), mp 218—220 °C. The Beilstein test gave a postive result. Found: C, 57.30; H, 6.69; N, 2.68%. Calcd for $C_{29}H_{40}NO_5I$: C, 57.12; H, 6.62; N, 2.30%. IR, 1710 and 1655 (α,β-unsaturated carbonyl), 1628 (*N*-acetyl), 1112 (C–O), 928, 910, and 890 cm^{-1}; NMR, τ 4.48 (1H, broad s, $W_{1/2}$= 3.9 Hz, 3-H), 5.55 (1H, dd, J=4.5 and 12.3 Hz, 6β-H), 5.84 and 6.25 (each 1H, AB quartet, J=7.6 Hz), 7.77 (3H, s, 18-H), 7.91 (3H, s, N-Ac), 8.96 (3H, d, J=6.3 Hz, 21-H), 9.08 (3H, s, 19-H), and 9.13 (3H, d, 26-H); MS, *m/e* (rel intensity), 609 (M^+ 0.4), 482 (M^+-I, 0.7), 167 (100), 152 (8.7), 74 (14.7), 59 (26.9), 45 (17.4), and 43 (8.4).

Product **6** was recrystallized from diethyl ether to yield crystals (8 mg), mp 165—167 °C. Found: C, 73.82; H, 8.73; N, 2.98%; M^+*m/e* 453.2842. Calcd for $C_{28}H_{39}NO_4$: C, 74.17; H, 8.67; N, 3.10%; M^+453.2877. IR, 1712 and 1671 (α,β-unsaturated carbonyl), 1624 (*N*-acetyl), 1262, 1100, and 904 cm^{-1}; NMR, τ 4.57 (1H, d, J=3.0 Hz, 6-H), 5.81—7.20 (9H, m, 2-H, 4-H, 9α-H, 22β-H, 23α-H, and 27-H), 7.77 (3H, s, 18-H), 7.92 (3H, s, N-Ac), 8.89 (3H, s, 19-H), 8.97 (3H, d, J=6.6 Hz, 21-H), and 9.14 (3H, d, J=7.5 Hz, 26-H); MS, *m/e* (rel intensity),453 (M^+, 0.5), 167 (100), and 152 (15.4).

Product **7** was recrystallized from diethyl ether to yield crystals (8 mg) mp 258—260 °C. Found: 481.2800. Calcd for $C_{29}H_{39}NO_5$: M, 481.2826. IR 1737 (7-membered lactone), 1712, and 1633, shoulder (α,β-unsaturated carbonyl), 1624 (*N*-acetyl), 1277, and 1028 cm^{-1}; NMR, τ 4.21 (1H, d, J= 3.0 Hz, 6-H), 5.36 and 5.84 (each 1H, AB quartet, J=13.5 Hz, 4a-H), 7.78 (3H, s, 18-H), 7.94 (3H, s, N-Ac), 8.94 (3H, s, 19-H), 8.97 (3H, d, J=6.6 Hz, 21-H), and 9.15 (3H, d, J= 6.9 Hz, 26-H); MS, *m/e* (rel intensity), 481 (M^+, 0.6), 167 (100), and 152 (14.7%).

Product **4** was recrystallized from acetone to yield crystals (201 mg), mp 216—218 °C. Found: C, 74.32; H, 8.80; N, 2.82. Calcd for $C_{58}H_{80}N_2O_8$: C, 74.64; H, 8.64; N, 3.00%. FD MS, (rel intensity), *m/e* 933 (M^++1, 100), 932 (43.4), 931 (26.9), 918 (M^+-CH_3, 21.0), and 777 (17.2); MS, (rel intensity), 467 (0.5), 466 (0.4), 465 (0.7), 330 (4.9), 167 (100), and 151 (10.6); IR, 1713 and 1633 (α,β-unsaturated carbonyl), 1659 (*N*-acetyl), 1094, 1074, 1032, and 762 cm^{-1}; NMR, τ 4.45 (1H, broad, s, 6-H of *N*-acetyl-11-oxojerva-5,12(13)-dien-3β-yl portion), 4.69 (1H, broad, s, 6-H of *A*-homo-4-oxa-11-oxojerva-5,12(13)-dien-3α-yl portion), 5.12 (1H, t, J=5.3 Hz, 3β-H of *A*-homo-4-oxa portion), 5.68 and 6.48 (each 1H, AB quartet, J=13.5 Hz, 4a-H of *A*-homo-4-oxa-11-oxojerva-5,12(13)-dien-3α-yl portion), 7.75 (6H, s, 18- and 18′-H), 7.92 (6H, s, *N*-acetyl and *N*′-acetyl), 8.97 (6H, d, J=6.6 Hz, 21-H and 21′-H), 9.00 (6-H, s, 19-H and 19′-H) and 9.14 (6H, d, J=7.5 Hz, 26-H and 26′-H).

Hydrolysis of N-*Acetyl-11-oxojerva-5,12(13)-dien-3β-yl* A-*Homo-4-oxa-11-oxojerva-5,12(13)-dien-3α-yl Ether with Aqueous Methanolic Hydrochloric Acid.* A suspension of the dimer (100 mg) in methanol (30 ml) containing concd hydrochloric acid (1 ml) was stirred at room temperature. The crystals gradually dissolved over a period of 1 h. The solution was stirred at room temperature for four more hours. After the addition of water, methanol was removed at room temperature and solution was extracted with chloroform. The chloroform solution was washed with aq sodium carbonate solution, washed with water, and dried over anhydrous sodium sulfate. The usual work-up of the solution left a residu e which showed two spots on a TLC plate (SiO_2) (a 8:1 mixture of chloroform–acetone). The product was subjected to preparative TLC to give two products. The more TLC mobile product (39 mg) was recrystallized from acetone to yield a compound which was identical with *N*-acetyljervine. The less TLC mobile amorphous product (45 mg) could not be induced to crystallise. IR, 3380 (OH), 1706, and 1620, broad, (α,β-unsaturated carbonyl and *N*-acetyl), 1100, 1056, and 1025 cm^{-1}; NMR, τ 4.41 (1H, d, J=3.9 Hz), 4.86 (1H, t, J=6 Hz), 5.59 and 6.41 (each 1H, AB quartet, J=13.3 Hz, 4a-H), 7.76 (3H, s, 18-H), 7.91 (3H, s, N-Ac), 8.96 (3H, d, J=6.6 Hz, 21-H), 9.01 (3H, s, 19-H), and 9.14 (3H, d, J=7.2 Hz, 26-H); MS, *m/e* 483 (M^+).

Oxidation of N-*Acetyljervine with Jones Reagent.* To *N*-acetyljervine (652 mg) in acetone (40 ml) there was added Jones reagent dropwise until the solution turned brown. The solution was stirred for a few min. On addition of water (250 ml), crude 3-ketone crystallized out from the solution. The crystals were collected by filtration, washed with water and recrystallized from acetone to yield 255 mg of pure 3-ketone **3**, mp 172.5—174.5 °C. Found: *m/e* 465.2860. Calcd for $C_{29}H_{39}NO_4$: M, 465.2877. IR, 1714, 1640 (shoulder) and 1627 cm^{-1}(six-membered ring ketone, and α,β-unsaturated carbonyl), 1244, 1148, and 1096 cm^{-1}; NMR, τ 4.63 (1H, broad, s, 6-H), 7.73 (3H, s, 18-H), 7.91 (3H, s, NAc), 8.93 (3H, s, 19-H), 8.93 (3H, d, J=6.6 Hz, 21-H), and 9.12 (3H, d, J=7.2 Hz, 26-H); MS, *m/e* (rel intensity), 465 (M^+, 0.7), 167 (100), 152 (15.5), and 43 (14.4).

*Preparation of 3α-Deuterio-*N*-acetyljervine (2).* The 3-ketone (202 mg) in ethanol (40 ml) containing sodium borodeuteride (148 mg) was stirred for 50 min. After the addition of water, the solvent was evaporated and the residue was dissolved in chloroform. The chloroform solution was washed with water and dried over anhydrous sodium sulfate. The usual work-up of the solution gave a product which was recrystallized from acetone–diethyl ether to yield 3β-ol, **2**, mp 224.5—226.5 °C. Found: *m/e* 468.3086. Calcd for $C_{29}H_{40}DNO_4$: M, 468.3097. IR, 3407 (OH), 1712 and 1649 (α,β-unsaturated carbonyl), 1628 (NAc), and 960 cm^{-1}; NMR, τ 4.64 (1H, d, J=4.5 Hz, 6-H), 7.76 (3H, s, 18-H), 8.91 (3H, s, N-Ac), 8.96 (3H, d, J=6.6 Hz, 21-H), 9.00 (3H, s, 19-H), and 9.13 (3H, d, J=7.5 Hz); MS, *m/e* (rel intensity) 468 (M^+, 0.6), 167 (100), and 152 (8.7).

*The Irradiation of 3α-Deuterio-*N*-acetyljervine Hypoiodite in the Presence of Mercury(II) Oxide and Iodine.* 3α-Deuterio-*N*-acetyljervine (147 mg), mercury(II) oxide (157 mg), and iodine (243 mg) in benzene (30 ml) in a Pyrex vessel were irradiated for 26.5 h as in the case of *N*-acetyljervine. The usual work-up of the reaction product gave a product which was subjected to preparative TLC (SiO_2) with a 7 : 1 mixture of chloroform and acetone. The crude product (58 mg) was recrystallized from diethyl ether to yield a pure dimer incorporating deuterium. It had a mp of 220—222 °C. FD-MS, *m/e* (rel intensity), 936 (M^++D, 78.2), 935 [$(M+H)^+$, 100], 934 (M^+, 91.1), 878 (20.8), and 769 (16.5): IR, 1713 and 1633 (α,β-unsaturated carbonyl), 1659 (*N*-acetyl), 1104, 1065, and 1039 cm^{-1}; the NMR spectrum was identical with that of the corresponding dimer from *N*-acetyljervine, with the exception of the absence of a 1H triplet at τ 5.12.

*The Irradiation of 3β-Hydroxy-17α-ethyletiojerv-5-ene-11,20-dione (**11**) in Benzene Containing Mercury(II) Oxide and Iodine.* 3β-Hydroxy-17α-ethyletiojerv-5-ene-11,20-dione (**11**) (300 mg) in benzene (51 ml) containing mercury(II) oxide (581 mg) and iodine (695 mg) was irradiated for 5 h at room temperature under an argon atmosphere while stirring. The reaction mixture was worked up as usual. The product was a complex mixture and showed a pattern of spots on TLC similar to a mixture from *N*-acetyljervine. The product was subjected to preparative TLC (chloroform–acetone, 20 : 1) to give six fractions (A–F in the order of decreasing mobility). The most mobile product A (100 mg) was an amorphous formate **12**. IR ($CDCl_3$), 1724 (broad, formyl carbonyl, 11-carbonyl and 20-carbonyl) and 1162 cm^{-1} (formyl C–O); NMR, τ1.89 (1H, s, OCHO), 4.03 (1H, d, J=5.4 Hz, 6-H), 5.39 (2H, broad s, $W_{1/2}$=3.6 Hz, C-3 methylene), 6.93 (2H, m, C-2 methylene), 7.84 (3H, s, 17α-acetyl), 8.82 (3H, d, J=6.0 Hz, 18-H), and 8.94 (3H, s, 19-H). MS, *m/e* 469 (M^+). The fractions B (44 mg) and C (14 mg) were a mixture. The fraction D (57 mg) was crystals; they were identified to be a dimeric acetal **13**. After recrystallization from acetone it had a mp of 250—253 °C. Found: *m/e* 658.4229. Calcd for $C_{42}H_{58}O_6$: M, 658.4232. IR, 1727 (11-carbonyl), 1703 (20-carbonyl), and 1034 cm^{-1} (C–O); NMR, 4.39 (1H, d, J= 4.5,6- H of *A*-homo-17α-ethyletiojerv-5-ene-11,20-dion-3α-yl portion) 4.65 (1H, d, J=4.5, 6-H of 17α-ethyletiojerv-5-ene-11,20-dion-3β-yl portion, 5.14 (1H, t, J=6 Hz, 3β-H of *A*-homo-17α-ethyletiojerv-5-ene-11,20-dion-3α-yl portion), 5.75 and 6.50 (each 1H, d, J=12.8 Hz, 4a-methylene of *A*-homo-17α-ethyletiojerv-5-ene-11,20-dion-3α-yl portion), 7.85 (6H, s, two acetyls), 8.79 (3H, d, J=6.0 Hz, 18-H), 8.83 (3H, d, J=6.0 Hz, 18′-H), and 8.97 (6H, s, superimposed 19-H). MS (rel intensity), *m/e* 658 (M^+, 0.4), 347 (1.6), 346 (1.5), 329 (100), 312 (46.8), 311 (29.2), and 269 (31.2).

The fraction E (20 mg) was *A*-homo-4-oxa-17α-ethyletiojerv-5-ene-3,11,20-trione (**14**). IR ($CHCl_3$) 3440 (hydroxy), 1735 (11-carbonyl and lactone), and 1705 (20-carbonyl); NMR, τ 4.6 (1H, d, J=4.5 Hz, 6-H), 5.27 and 5.72 (each 1H, d, J= 13.5 Hz, 4a-H), 7.83 (3H, s, 21-H), 8.81 (3H, d, J=6.0 Hz, 18-H), and 8.87 (3H, s, 19-H). MS, *m/e* 342 (M^+).

The authors are grateful to Mrs. Satoko Araki and Mrs. Tomoko Okayama for the measurements of the ^1H NMR spectra and the spin decoupling experiments.

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