253. A *Norrish* Type I Cleavage in the Photolysis of a Steroidal α,β-Unsaturated δ-Lactone[1])

Photochemical Reactions. XIV [1]

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Summary

The UV. irradiation of 17β-acetoxy-4-oxa-5α-androst-1-en-3-one (**1**) yields A,B-*diseco*-steroids originating from a *Norrish I* process of the lactone function.

Introduction. – The photochemical behaviour of α,β-unsaturated δ-lactones has been mainly studied in coumarins [2]. In the monocyclic series, *Matsuo et al.* have reported addition of the solvent in the irradiation of 5,6-dihydro-6-methyl-2*H*-pyran-2-one [3]. Recently, we have been able to show that the 2-oxa-Δ^4 and 4-oxa-$\Delta^{1,5}$ steroidal lactones undergo, respectively, the type A [4] and di-π-methane [5] photorearrangements in a similar way to their carbocyclic counterparts. In this paper we describe the results obtained in the irradiation of the Δ^1-lactone **1**.

Photolysis of *1*. – The UV. irradiation ($\lambda = 254$ nm) of **1** [6] in methanol yielded a mixture of the aldehydoester **2** (50%), its acetal **3** (6%) and starting material **1** (13%), together with impurities of higher polarity originating from the decomposition of **2** (24%) *(Scheme 1)*. When the irradiation was carried out in *t*-butyl alcohol, only the aldehydoester **4** (34%) was isolated, together with starting material **1** (10%) and mixtures of unidentified products of high polarity (40%).

Treatment of the aldehyde **2** with *p*-toluenesulfonic acid in methanol yielded **3**. As an independent synthesis of **3**, the *seco*-lactam **5** [1] was hydrolyzed to the aldehydoacid **6** (not isolated owing to its instability) and then treated, successively, with *p*-toluenesulfonic acid in methanol and acetic anhydride in pyridine, to yield a compound which was identified as the photoproduct **3**. Although unknown, the geometry of the double bond ought to be the same in **2**, **3** and **5**.

Discussion. – The formation of **2** from **1** can be rationalized assuming that α-cleavage occurs to produce the primary diradical A *(Scheme 2)*, which then rearranges to the ketene **B**. Solvent addition would yield **2**. This cleavage is a typical

[1]) Part of the doctoral thesis of *A. Cánovas*, I.Q.S., Barcelona, 1980.

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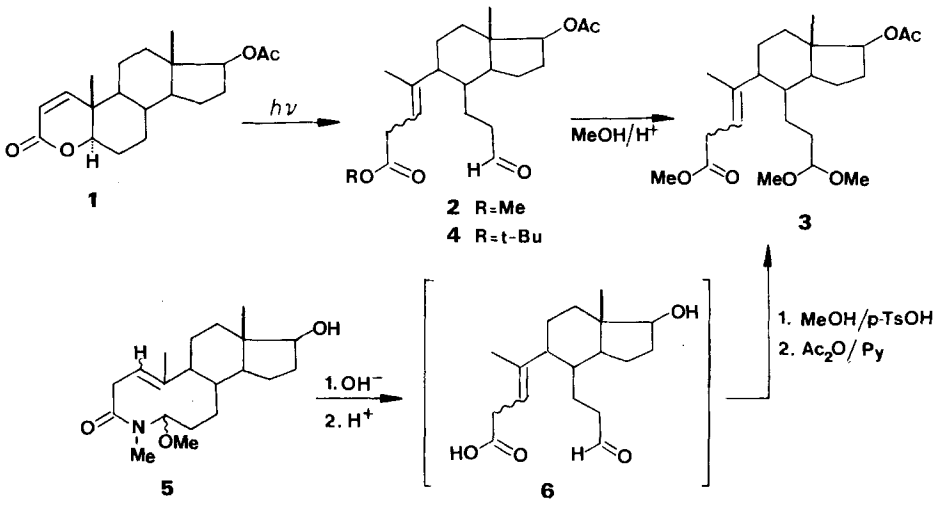
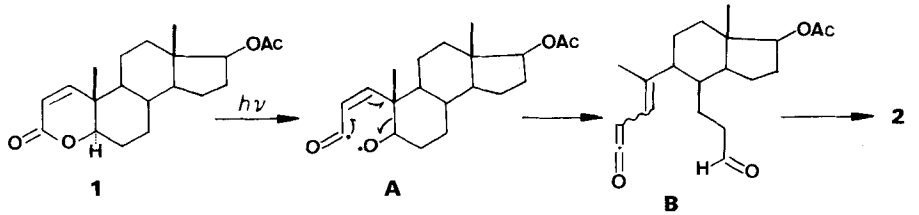
Scheme 1



Scheme 2



process in the photolysis of enol lactones [7]. In the present case, the further breaking of the C(10)–C(5) bond could be attributed to the presence of the Δ^1 double bond in **A**.

The acetal **3** is formed in a thermal reaction catalyzed by traces of formic acid produced by the irradiation of methanol in the presence of O_2 or air [8]. Thus when the irradiation was carried out in methanol containing Na_2CO_3 or with short irradiation time (low conversion of **1**), no acetal was detected. Furthermore, when **2** was added in the dark to methanol previously irradiated with UV. light, the formation of the acetal **3** could be detected after 24 h (TLC.). Also, in the irradiation in *t*-butyl alcohol, which does not generate acid in these conditions, no acetal derivative of **4** has been detected.

Transformation **1**→**2/4**, constitutes a novel type of reaction of ring A steroidal lactones, which causes considerable modification of its skeleton.

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Experimental Part

General remarks: [5].

Photolysis of 1. – a) *In methanol.* A solution of 800 mg of **1** in 160 ml of dry MeOH, was irradiated during 72 h with a low-pressure Hg-lamp. Solvent evaporation *in vacuo* yielded 867 mg of a mixture. Chromatography in cyclohexane/ethyl acetate 11:4, furnished, first, 62 mg of *methyl 17β-acetoxy-5,5-dimethoxy-A-nor-3,5*-seco-*5,10*-seco-*1(10)-androsten-3-oate* (**3**), as an oil. – UV.: end absorption. – IR. (film): 1735, 1655, 1245, 1050. – ^{1}H-NMR.: 0.70 (*s*, $H_3C(18)$); 1.55 (br. *s*, $H_3C(19)$); 2.00 (*s*, AcO); 3.00 (*d*, $J=8$, $H_2C(2)$); 3.23 (*s*, 2 CH_3O); 3.65 (*s*, $COOCH_3$); 4.20 (*m*, H–C(5)); 4.60 (*m*, H–C(17)); 5.30 (*t*, $J=8$, H–C(1)). – MS.: 410 (M^+).

$C_{23}H_{38}O_6$ (410.56) Calc. C 67.29 H 9.33% Found C 67.19 H 9.36%

The second fraction consisted of 329 mg of *methyl 17β-acetoxy-5-oxo-A-nor-3,5*-seco-*5,10*-seco-*1(10)-androsten-3-oate* (**2**), as an oil. – UV.: end absorption. – IR. (film): 2700, 1730, 1650. – ^{1}H-NMR.: 0.68 (*s*, $H_3C(18)$); 1.50 (br. *s*, $H_3C(19)$); 1.95 (*s*, AcO); 2.97 (*d*, $J=8$, $H_2C(2)$); 3.60 (*s*, $COOCH_3$); 4.50 (*m*, H–C(17)); 5.30 (*t*, $J=8$, H–C(1)); 9.60 (*t*, $J=1$, HCO). – MS.: 364 (M^+). Its unstability on purification prevented its elemental analysis.

The third fraction contained 230 mg of a mixture of **2** and starting material **1**, which was further chromatographed with cyclohexane/ethyl acetate 11:4 to obtain 115 mg of **2** (mixed m.p., TLC., and IR.) and 102 mg of **1** (mixed m.p., TLC., and IR.). The fourth fraction, 215 mg of a mixture of polar components, was not further investigated.

b) *In* t-*butyl alcohol.* A solution of 305 mg of **1** in 160 ml of *t*-butyl alcohol (*Merck*, analytical purity) was irradiated during 68 h, with a low-pressure Hg-lamp. Solvent evaporation *in vacuo* yielded 339 mg of a mixture of several components. Chromatography in cyclohexane/ethyl acetate 11:4 furnished, first, 93 mg of t-*butyl 17β-acetoxy-5-oxo-A*-nor-*3,5*-seco-*5,10*-seco-*1(10)-androsten-3-oate* (**4**), as an oil. – UV.: end absorption. – IR. (film): 2700, 1735, 1245. – ^{1}H-NMR.: 0.70 (*s*, $H_3C(18)$); 1.35 (*s*, $COOC(CH_3)_3$); 1.50 (br. *s*, $H_3C(19)$); 1.95 (*s*, AcO); 2.90 (*d*, $J=8$, $H_2C(2)$); 4.55 (*m*, H–C(17)); 5.30 (*t*, $J=8$, H–C(1)); 9.60 (*t*, $J=1$, HCO). – MS.: 349 (M^+-59). Its unstability on purification prevented its elemental analysis.

The second fraction consisted of 60 mg of a mixture of **4** and starting material **1**, which was further chromatographed with cyclohexane/ethyl acetate 11:4, to yield 25 mg of **4** and 30 mg of **1**. The third fraction contained 158 mg of a mixture of polar compounds, that was not further investigated.

Synthesis of 3. – a) *From* **2**. To 15 mg of **2** in 5 ml MeOH, a crystal of *p*-toluenesulfonic acid was added. The solution was left during 4 h at RT. After partial solvent evaporation *in vacuo*, the usual work-up, washing with aq. $NaHCO_3$-solution, yielded 17 mg of **3** pure (mixed TLC. and IR. spectrum).

b) *From* **5**. To a solution of 20 mg of **5** in 5 ml MeOH, 5 ml of aq. 4N NaOH were added. The mixture was refluxed for 6 h. MeOH evaporation *in vacuo* and the usual work-up, after acidification, yielded **6**. The crude, in 5 ml MeOH and a crystal of *p*-toluenesulfonic acid, was left 26 h at RT. MeOH evaporation *in vacuo* and the usual work-up, washing with aq. $NaHCO_3$-solution, afforded an oily compound. Acetylation of this oil with 3 ml Ac_2O/pyridine 1:1 yielded 23 mg of a mixture containing one major component with impurities. Filtration through silica gel *Merck* ('reinst'), in cyclohexane/ethyl acetate 11:4 gave 17 mg of **3** pure (mixed TLC., IR. and MS. spectra) and 6 mg of a mixture of higher polarity compounds, not further investigated.

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