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OXIDATIVE PHOTOCHEMICAL DECARBONYLATION OF ALDEHYDES[1]

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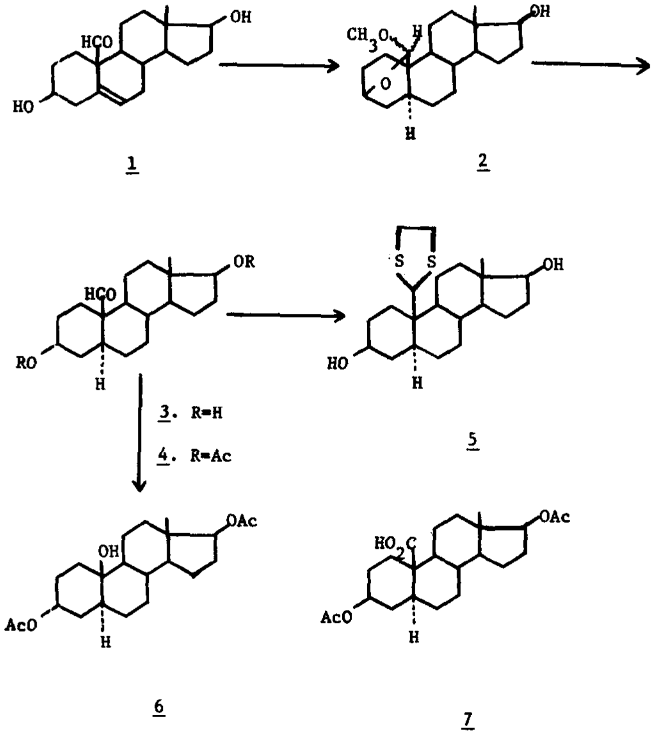
Disclosures of the photochemical decarbonylation of steroidal Δ^5-19-aldehydes and saturated 19-aldehydes have appeared recently[2,3,4]. In the case of Δ^5-compounds, the reaction was described as unaffected by oxygen, whereas when 3,3,17,17-bisethylenedioxy-5α-androstane was irradiated in the presence of oxygen, unknown polar products thought to be 10-hydroperoxides were said to be formed[3,4]. The latter reaction also has been investigated in this laboratory in the course of our work on C-19 functional steroids, and these results, which differ from those already described, are now presented.

Catalytic reduction (10% Pd-C in methanol) of 19-oxoandrost-5-~~ene~~-3β, 17β-diol[5] gave the acetal 2[6], m.p. 154-156°, $[\alpha]_D^{25}$ + 35°, which was a mixture of C-19 epimers as shown by the n.m.r. spectrum. Hydrolysis of 2 (1% HCl in methanol-water) gave the crude aldehyde 3, which partially formed the corresponding acetal epimer mixture, m.p. 154-172° when recrystallized (acetone-hexane). The configuration at C-5 in 3 was established by formation of the thioketal 5, isolated as the stable ethyl acetate solvate m.p. 113-115°, $[\alpha]_D^{20}$ + 24°. Reductive desulfurization of 5 gave 5α-androstane-3β,17β-diol, identical with an authentic sample.


OH
HCO
HO
1
CH3O
H
OH
O
H
2
OR
HCO
RO
H
3. R=H
4. R=Ac
S S
OH
HO
H
5
OAc
OH
AcO
H
6
OAc
HO2C
AcO
H
7

Acetylation of 3 gave 4, m.p. 116-117° $[\alpha]_D + 6$, λ_{max}^{EtOH} 308 mμ ($\epsilon = 26$). A solution of 4 in ethyl acetate was irradiated under a stream of oxygen for 0.5 hr. at 25° with a high pressure mercury arc (Hanovia 450 w.). At the end of this period no starting material remained (gas chromatography). There was isolated the acid 7 (50%), m.p. 193-194°, $[\alpha]_D^{20} - 4.0°$, and 20% of a second product $C_{22}H_{34}O_5$ (mass spectrometry), m.p. 174-175°, $[\alpha]_D^{20} - 21°$ n.m.r. (cps, 100 mc in deuteriobenzene*) 78 (C-18-H), 174, 176 (acetate methyls), 462, 470, 471, 479 (quartet, 17α-H), 450-480 (broad hump, 3α-H), no aldehyde proton. A hydroxyl band (3500 cm^{-1}) was present in the infrared spectrum. These data are consistent only with structure 6. The configuration at C-10 follows from the A/B trans fusion which was deduced from the n.m.r. evidence[7] for an axial proton at C-3.

The activating wave length was shown to be the $n \rightarrow \pi^*$ transition at 308 mμ by the use of filters. Azoisobutyronitrile could be used to initiate the reaction without light, whereas tolylthiol inhibited the reaction. The reaction proceeded during several days in room light under atmospheric oxygen.

The simplest sequence which accommodates these data is photochemical oxidation of the aldehyde to the corresponding peracid[8] or a related excited species. Disproportionation of this product to form 6,7, and carbon dioxide would follow[9]. The fact that no formate ester of 6 was observed by gas chromatography argues against a Baeyer-Villiger mechanism. A stereospecific hydroxyl transfer and a chain mechanism clearly are involved, but it is not possible to state which portions of the

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process are ionic and which are free radical in nature. Likewise, the stereospecificity could be explained equally well by a concerted or tight pair scheme.

It would appear that the autoxidation of strophanthidin[10] involves a similar reaction and that the 5β-hydroxyl group is, therefore, not essential for this degradation.

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